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VOLUME 54

1947

PUBLISHERS

AMERICAN MEDICAL ASSOCIATION

CHICAGO ILL

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EFFECT OF ESTROGENIC HORMONE ON ADVANCED CARCINOMA OF THE FEMALE BREAST

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AND

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THE FAVORABLE results obtained by a group of English investigators¹ from the use of estrogenic hormones in some cases of advanced carcinoma of the female breast prompted us to try this therapeutic procedure. We selected 17 patients for study. Thirteen patients had primary inoperable cancer, for which no previous therapy had been administered. Two patients had recurrent lesions in the same breast several years after treatment of inoperable carcinoma by irradiation. Of the remaining 2 patients of this group, a carcinomatous ulcer had developed in the mastectomy scar of 1 and recurrent nodules in the skin of the thoracic wall of the other. A biopsy specimen which was positive for cancer was obtained in every case.

These 17 patients were treated exclusively with a synthetic estrogenic hormone (ethinyl estradiol) administered orally. One milligram of this substance, according to some investigators,² is the equivalent of 7 to 20 mg. of diethylstilbestrol. In the present investigation the dose of ethinyl estradiol varied from 0.15 to 0.7 mg. daily. On the basis of the lower figure given previously, this would be equivalent to at least 1.0 to 5.0 mg. of diethylstilbestrol daily.

The data in connection with these 17 patients have been tabulated (table). The ages of these women ranged from 40 to 77 years. Five patients were younger than 60 years. The 40 year old patient was the only one who was not in the postmenopause period. The duration of the estrogen treatment varied from two to eleven months.

From the Breast Department of the Memorial Hospital for the Treatment of Cancer and Allied Diseases.

1 (a) Discussion on Advanced Cases of Carcinoma of the Breast Treated with Stilbestrol, Proc. Roy. Soc. Med. 37:731, 1944. (b) Haddow, A., Watkinson, J., and Paterson, E. Influence of Synthetic Oestrogens upon Advanced Malignant Disease, Brit. M. J. 2:393, 1944.

2 Soule, S. A Clinical Trial of Ethinyl Estradiol, Am. J. Obst. & Gynec. 45:315, 1943. Allen, W. The Biological Activity of Various Estrogens, South. M. J. 37:270, 1944.

Summary of Sixteen Cases Treated by *Istrophen Hormone*

Case	Age	Sex	Status before Therapy	Average Daily Dose	Total Dose Mks.	Duration of Therapy	Course	
							No change in 1 hour	after institution of therapy
1	41	F	Masses in left breast and axilla bilateral intracapsular nodes pulmonary metastases postmenopausal	0.1	1.6	6 wk.	No change in 1 hour	after institution of therapy
2	41	F	Localized mastectomy on right side 3 yr previous by mass in left breast axilla and intracapsular space postmenopausal	0	1	6 mo.	Mass increased until whole left breast was involved nodules developed in breast skin uterine bleeding induced serial histologic specimens revealed cytologic changes died 1 yr after institution of estrogen therapy	
3	41	F	Mass occupying entire right breast flat axillary and right intracapsular node menstruating regularly	0.1	1.1	11 wk.	In uterus (phenomenon developed in right breast metastases to left breast and lungs died 1 mo after institution of hormone therapy	
4	41	F	Mass in left breast axilla and supraclavicular space postmenopausal	0.1	1.0	6 mo.	Mass in breast and axilla increased in size metastases to right axilla developed uterine bleeding induced died 8 mo after institution of hormone therapy	
5	41	F	Mass occupying whole right breast cutaneous nodules right axillary and left intracapsular nodes postmenopausal	0.1	1.1	5 mo.	In uterus (phenomenon developed in right breast pulmonary metastases uterine bleeding induced died 10 mo after institution of hormone therapy	
6	41	F	Fungating mass involving one third of breast extensive pulmonary metastases postmenopausal	0.1	1.7	11 mo.	Increase in size and extent of fungating mass decrease in number density and extent of pulmonary metastases uterine bleeding induced specimens for serial biopsies revealed no change died 19 mo after institution of hormone therapy	
7	41	F	Infiltrate left breast involved bilateral axillary nodes edema of the left arm postmenopausal	0.1	2.0	6 mo.	Nodules in skin of left breast and edema of legs developed no uterine bleeding specimens for serial biopsies revealed no change died 7 mo after institution of hormone therapy	
8	41	F	Ulcer in mastectomy scar on right side hard mass in right axilla numerous skin nodules postmenopausal	0.15	9.15	1 mo.	Base of ulcer on thoracic wall healed biopsy specimens revealed no cytologic change uterine bleeding induced general condition good 9 mo after institution of estrogen therapy	
9	41	F	Ulcerated mass in upper outer quadrant of left breast metastases to spine pelvis ribs femurs and skull paralysis of the right side of the face postmenopausal	0.20	10.8	2 mo.	Grew progressively worse repeat roentgenograms revealed increase in extent of metastases uterine bleeding induced specimens for serial biopsies revealed no change died 6 mo after first clinic visit	

10	65	Nodular mass in left breast, skin red, impending ulceration a few 1 cm lymph nodes in left axilla, post menopause	7.15	50.1	1 mo	Area of softening, became smaller, gained 8 pounds in weight, active uterine bleeding induced, general condition good 7 mo after institution of estrogen therapy
11	61	Right breast and overlying skin completely infiltrated with cancer, axillary mass on right side, edema of the right arm pulmonary metastases post menopause	0.5	20.0	2 mo	Patient recited, tumors of chest after 2 mo of estrogen treatment revealed diminution in size of metastases, breast lesion unchanged, no uterine bleeding, specimen for serial biopsies revealed no change, general condition is good 1 mo after institution of estrogen therapy
12	60	Mass protruding from left breast, ulceration imminent, firm nodes in left axilla metastasis to lungs and pelvis	0.0	7.0	2 mo	Mass in left breast decreased in size general condition good 1 mo after institution of estrogen therapy no uterine bleeding
13	63	Mass in left breast, with small area of ulceration postmenopause	0.5	28.0	2 mo	Ulceration healed completely uterine bleeding induced specimens for serial biopsies revealed no change, condition good 1 mo after institution of estrogen therapy
14	71	Left breast and skin widely infiltrated with carcinoma, postmenopause	0.5	17.5	5 wk	Uterine bleeding developed, not able to return to elute specimens for serial biopsies failed to reveal cytologic changes
15	77	Left breast shrunken, filled with hard mass large ulceration 2 cm node in left axilla postmenopause	0.5	12.0	mo	Ulceration filled in mass grew smaller axillary node disappeared, no uterine bleeding, specimens for serial biopsies revealed no change in good condition 1 mo after institution of estrogen therapy
16	67	Impending masses occupying most of right breast, left breast involved by inflammatory carcinoma extending onto abdomen, numerous bilateral supra clavicular nodes postmenopause	0.5	20.0	2 mo	Local condition increased in extent, general condition good 2 mo after institution of estrogen therapy, no uterine bleeding
17	71	Simple mastectomy 8/20/15, recurrent skin nodules 1/1/16 postmenopause	0.7	2.2	2 mo	Condition essentially unchanged 2 mo after institution of estrogen therapy

RESULTS

In this group of 17 patients 7 died of the disease from four to eighteen months after the institution of estrogen therapy. One died of coronary occlusion after six weeks of treatment. Five of the deceased patients were less than 60 years of age. Only 1 of the latter group (case 6) manifested a transient favorable response to the therapy. One patient, in poor condition when first seen at this clinic, was unable to return after five weeks of therapy because her condition rapidly deteriorated.

Seven of the total number of patients, or 40 per cent, exhibited some clinical improvement. Preexistent carcinomatous ulcers became smaller in cases 8 and 15 and healed completely in case 13. The changes produced in case 15 are shown in figure 1. In case 12 a protuberant nonulcerated cancer mass decreased in size (fig. 2). A diminution in the size of the breast mass and a solidification of an area of softening were exhibited in case 10. A decrease in the size and extent of pulmonary metastatic lesions was revealed in cases 6 and 11. This is shown in figures 3 and 4. The fungating lesion arising from the breast of the patient in case 6 continued to increase in size during the period of regression of the pulmonary lesions. This patient died eighteen months after the institution of estrogen therapy. The other 6 patients in this group are in apparent good condition. The disease has regressed in each instance, but in no case to date has it entirely disappeared. These patients have been under observation for periods ranging from four to nine months.

Although there was no clinical evidence of improvement in case 2, specimens for serial biopsies taken during the course of the treatment revealed cytologic changes. One biopsy specimen taken after five months of therapy was described by Dr. Fred Stewart as follows: "Mammary carcinoma infiltrating dermal lymphatic vessels and blood vessels is present. The appearance is slightly abnormal in that the nuclei look unusually hyperchromatic and irregular. The cytoplasm is unusually abundant and a little granular. Mitoses are abundant. There is nothing peculiar in the original tumor, hence these changes are definite."

The patients that responded favorably manifested the improvement within the first four to six weeks. It appeared that if favorable results were not obtained relatively early the continued use of the hormone would be ineffectual. Most of the women treated experienced a feeling of well-being while under estrogen therapy. A few gained in weight. One patient (case 10) gained 8 pounds (3.6 Kg.). Six of the 7 patients in whom favorable changes were produced by the hormone were over 60 years old.

The hormone induced uterine bleeding in 8 patients during the course of the treatment. On 1 occasion a severe hemorrhage occurred.

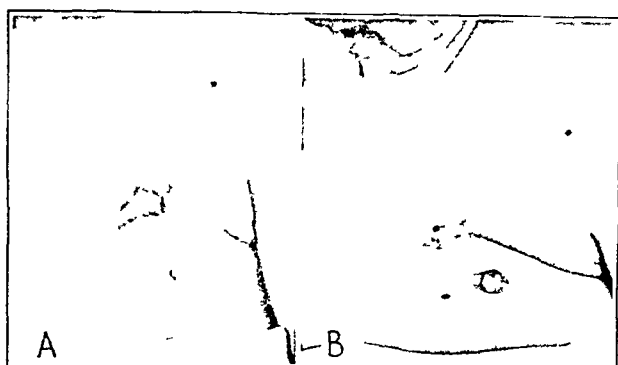


Fig 1 (case 15) —*A*, the left breast is seen to be filled with a nodular mass, above which is a large area of ulceration and lateral to this a smaller area of impending ulceration. *B*, this photograph was taken after two months of estrogen therapy. The mass in the breast has regressed decidedly. The ulcerated area has filled in and the area of impending ulceration has disappeared.

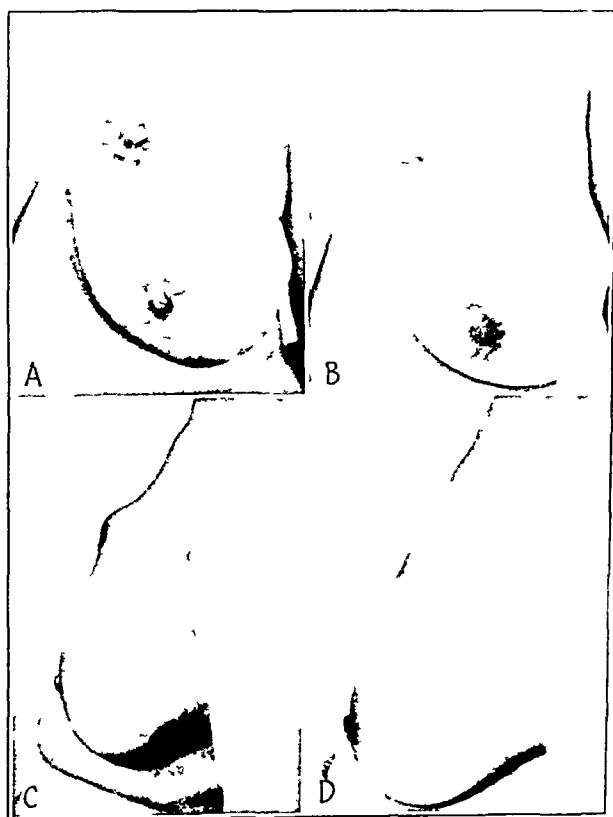


Fig 2 (case 12) —*A*, there is an area of impending ulceration at the medial aspect of the lesion. *B*, after two months of estrogen therapy the area of impending ulceration has disappeared. *C*, this is a profile view of the protuberant lesion shown in *A* before estrogen therapy was initiated. *D*, this is the profile view of the protuberant lesion after two months of estrogen therapy. A comparison with *C* reveals a striking regression of the lesion.

After two months of estrogen therapy vaginal smears³ were made in 6 patients (cases 11, 12, 13, 15, 16 and 17), the technic of Shorr⁴ and of Papanicolaou⁵ being followed. The cytologic changes associated with estrus which have been described by these investigators were present in each instance. In some of the women in the sixth and seventh decades the breasts became fuller and the overlying skin pink.

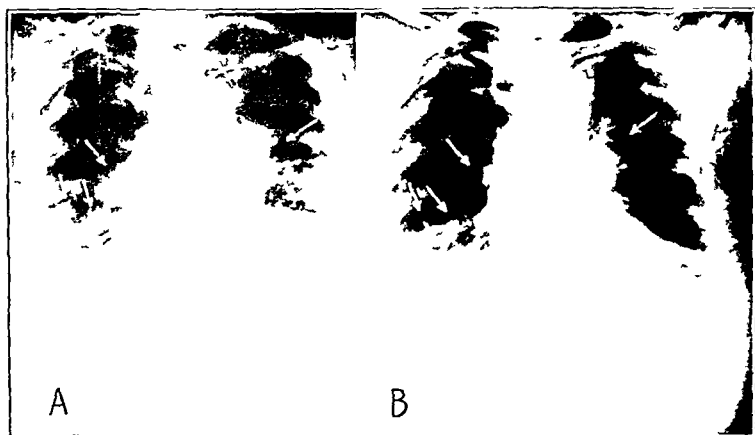


Fig 3 (case 6)—*A* extensive pulmonary metastases may be seen. *B* this roentgenogram was made after three months of estrogen therapy. The regression of the metastatic lesions may be seen by comparison with the preceding figure.

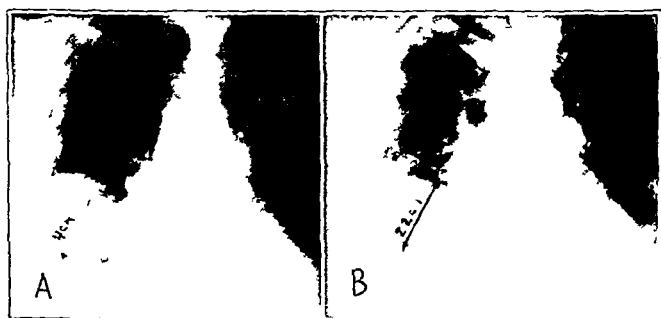


Fig 4 (case 11)—*A* there is a large metastatic area near the base of the right lung. *B*, this roentgenogram, taken after two months of estrogen therapy, shows the lesion at the right base to have decreased in size by almost one half.

3 Dr Anne C. Carter of the Department of Endocrinology, New York Hospital interpreted these smears.

4 Shorr, E. An Evaluation of the Clinical Application of the Vaginal Smear, *J Mt Sinai Hosp* 12:667, 1945.

5 Papanicolaou, G. The Sexual Cycle in the Human Female as Revealed by Vaginal Smears. *Am J Anat (supp)* 52:519, 1933.

Mild toxic reactions, which were evidenced by abdominal cramps and nausea, were experienced by most of the patients in the early stages of treatment, even with relatively small doses of the estrogen. A tolerance was quickly established, however, so that the dose could be increased rapidly. In 1 patient (case 7) edema of the legs and ankles developed, which was in all probability a toxic manifestation of the estrogen.

Monthly determinations of the serum calcium, phosphorus and alkaline phosphatase levels were made in all patients except 3 (cases 1, 14 and 17). In no case was there definite evidence that an alteration in the serum calcium or alkaline phosphatase contents was induced by estrogen therapy. There was a significant drop in the serum phosphorus level in 6 patients. In the remainder no appreciable change was noted. It is of interest that Buchwald and Hudson,⁶ working with male rats, found that a subcutaneous daily injection of diethylstilbestrol did not influence the serum calcium level but did produce an apparent decrease in the serum phosphorus content.

There were no significant changes noted in routine examinations of the blood and urine except in 1 patient (case 11). This patient had sugar (3 plus) in her urine at her initial visit to the clinic. A determination of blood sugar content revealed a hyperglycemia of 276 mg per hundred cubic centimeters. The patient had suffered from polyuria and nocturia for many months but was unaware of the cause. She had never received treatment, nor had she ever been on a low carbohydrate diet. She was asked to continue with her usual diet. No insulin was given. After two weeks of estrogen therapy her blood sugar content was 206 mg per hundred cubic centimeters, and at the end of six weeks of estrogen treatment it was 140 mg. Her urine at this time was sugar free, and the urinary symptoms had disappeared. She was eating carbohydrates in abundance.

COMMENT

The only group of patients with advanced carcinoma of the breast treated by estrogens reported to date is that of the English investigators.^{1a} In that symposium ten physicians pooled their cases, which totaled 100. Our findings do not differ essentially from theirs. An important point of agreement is that the favorable results are obtained predominantly in women above the age of 60.

The results of the present investigation suggest that estrogens have a decidedly deleterious effect on women in the younger age group.

6 Buchwald K, and Hudson L. The Biochemical Effects of Sex Hormones—Acid and Alkaline Phosphatase Activity, Calcium and Phosphorus. *Endocrinology* 35:73, 1944.

This appeared to be most striking in the 40 year old patient (case 3), who was menstruating regularly. When first seen in the clinic her general condition was good despite the mass in the right breast and right axilla. Roentgenograms revealed no evidence of disease in the lungs, lumbar portion of the spine or pelvis. Soon after the institution of the estrogen therapy her condition deteriorated. Within three months she was bedridden, and she died about one month later. A comparison of *A* and *B* in figure 5 reveals the progress of the disease in ten weeks. In figure 5 *B* the opposite breast is seen to be involved. This breast is edematous, and the nipple is retracted. The rapid progress of the disease may have been the result of a specific action of the estrogen, or it may have resulted from vascular changes produced in the breast by the hormone.

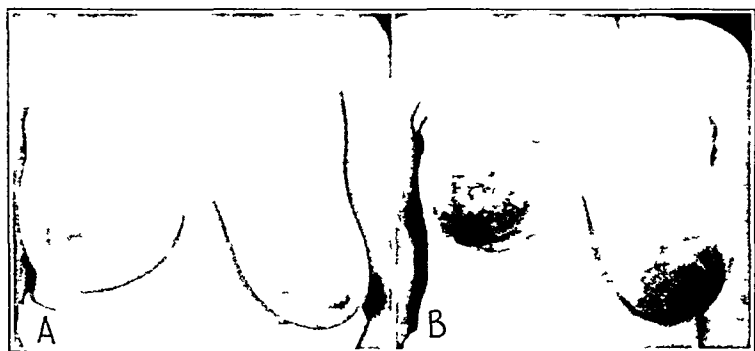


Fig 5 (case 3)—*A*, this is a photograph of the breasts before estrogen therapy was instituted. The deformity of the right breast, retraction of the nipple and pigskin appearance are clearly delineated. The left breast is apparently normal. *B*, this photograph was taken after ten weeks of estrogen therapy. Comparison with *A* reveals the striking change that has taken place in the right breast and also the edema, retraction of the nipple and pigskin appearance now present in the left breast.

Both estrogens and androgens⁷ apparently exert an inhibitory effect on carcinoma of the female breast. The pituitary gland may be the common denominator. Moore and Price⁸ have presented evidence that the pituitary may be influenced by the sex hormones. They found that gonadal hormones of either sex exert a depressing effect on the hypophysis of male rats, which results in a diminished amount of the

7 Adair, F., and Herrmann, J. The Use of Testosterone Propionate in Advanced Carcinoma of the Breast, *Ann Surg* 123 1023, 1946. Herrmann, J., Adair, F., and Woodard, H. Further Experience with Testosterone Propionate in Osseous Metastasis from Carcinoma of the Female Breast, to be published.

8 Moore, C. and Price, D. Gonad Hormone Functions and the Reciprocal Influence Between Gonads and Hypophysis with Its Bearing on the Problem of Sex Hormone Antagonism. *Am J Anat* 50 13 1932.

GRANULOMAS CAUSED BY SURGICAL SILK AND COTTON SUTURES

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INFECTION in clean wounds following the use of surgical silk or cotton sutures is relatively uncommon when careful technique is employed. When infection does occur, it is usually minimal and produces a small stitch abscess or sinus tract. In rare cases a late infection develops several months following the primary operation, which forms a small abscess about one or more sutures surrounded by granulation tissue and a dense wall of fibrous tissue.

The following 5 cases are examples of granulomatous lesions which developed after the use of surgical silk and cotton in clean wounds (fig.)

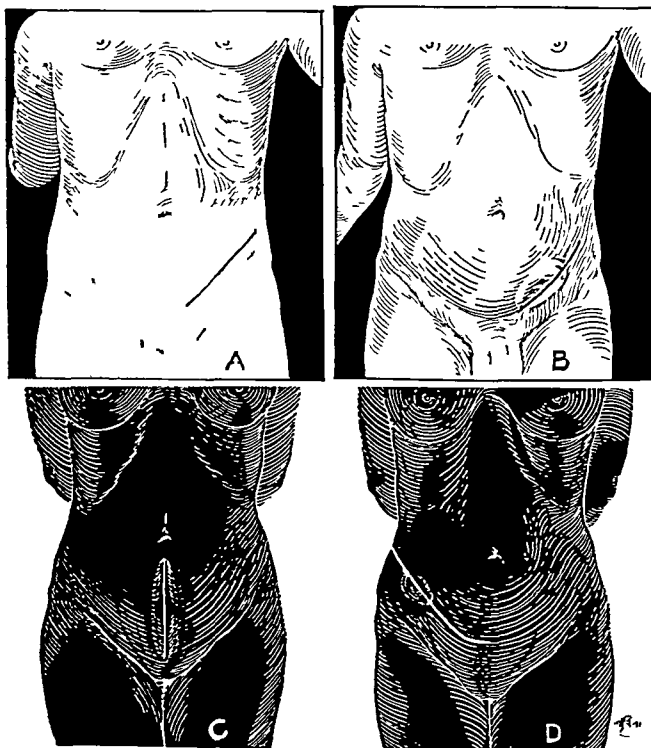
REPORT OF CASES

1—H. V., a youth aged 19, was operated on March 6, 1941, for an inguinal hernia on the left side. Size 000 interrupted surgical silk was used. Size 0000 surgical silk was used for ligatures. The wound healed per primam. Two months later some discomfort was noted in the region of the scar. A few days following the onset of the discomfort a swelling appeared beneath the lateral end of the scar. The swelling was tender, but pain was never severe. The patient was readmitted to the hospital July 3, 1941, approximately four months after his operation. A mass 6 by 8 cm. was visible and palpable beneath the lateral half of the scar. An incision was made through the scar, and a sinus tract was found extending from the aponeurosis of the external oblique muscle to the purse string suture used to ligate the neck of the hernial sac. An abscess 2 by 2.5 cm. surrounded the purse string suture. The purse string suture and two small sutures were removed from the abscess and sinus tract. A hemolytic staphylococcus was grown from a culture of pus.

CASE 2—R. S., a woman aged 28, was operated on Sept. 17, 1942, for an intestinal obstruction following a pelvic operation. The obstruction was released and a Witzel enterostomy was done above the site of obstruction. The enterostomy tube was sutured in the wound. The fasciae were closed with size 000 surgical silk. Size 0000 surgical silk was used for ligatures. The wound healed per primam. A sinus tract persisted after removal of the enterostomy tube on the eleventh postoperative day. The sinus tract did not heal until a stitch was removed six months after the operation. In December 1943, approximately fifteen months after the operation for intestinal obstruction a slightly tender swelling was noted beneath the scar. The swelling persisted until the patient's admission to the

hospital on June 25, 1944, twenty-one months after the operation. There was a mass beneath the abdominal scar measuring approximately 5 by 10 cm. The mass was firm and slightly tender. On exploration a small abscess cavity, surrounded by a thick fibrous wall, was found extending along the suture line in the fascia, which was filled with thick pus and granulation tissue. Nine surgical silk sutures were removed. Healing was prompt after removal of the surgical silk sutures and drainage.

CASE 3—A woman aged 60 was operated on Dec 29, 1944. A colectomy on the right side was done through an oblique incision in the lower part of the abdomen. The wound was closed in layers with size 000 surgical silk. Size 0000 surgical silk was used for ligatures. A drain was placed in the lateral end of



Locations of granulomas which developed from two to twenty-two months following the primary operations. *A* and *B*, inguinal hernias repaired; *C*, supra pubic incision for postoperative intestinal obstruction; *D*, oblique incision for resection of right side of the colon.

the incision. In August 1945, eight months after the operation, a painless swelling was noticed by the patient beneath the lateral third of the scar. She was readmitted to the hospital and a mass involving the scar, 4 by 5 cm, was excised on Oct 27, 1945, ten months after the primary operation. The mass was com-

posed of dense fibrous tissue, in the center of which a small abscess was found. Surgical silk sutures were found in the wall of the granulation tissue of the abscess. A culture of the pus from the abscess grew *Escherichia coli*. The report on examination of the tissue was acute and chronic granulation tissue and foreign body reaction.

CASE 4—A F, a man aged 67, was operated on March 15, 1944, for direct, indirect and femoral hernias on the left side. The three hernias were repaired with a McVay type of operation. Size 40 interrupted cotton sutures were used. Size 60 cotton was used for ligatures. The wound healed per primam. On Jan 13, 1946, twenty-two months after the operation for hernia, this patient was readmitted to the hospital, complaining of a tender swelling in the left inguinal region. The swelling and tenderness were first noticed two weeks before admission to the hospital. When examined, the swelling measured about 6 by 8 cm. It lay directly beneath the hernial scar. The entire area involved was indurated and tender. At operation an abscess containing thick pus and granulation tissue was drained. The abscess extended from the suture line in the aponeurosis of the external oblique muscle to the suture line along Cooper's ligament. Four cotton sutures were removed from the granulation tissue along the suture line in the external oblique aponeurosis. A hemolytic streptococcus was grown from a culture of the pus.

CASE 5—J T E, a man aged 50, was operated on for appendicitis in a hospital on the West Coast four years prior to his admission to the University of Kansas Hospitals on Aug 9, 1946. Three months before admission pain and tenderness developed beneath his abdominal scar following heavy lifting. During the three month period before his admission to the hospital, the tenderness persisted and a small mass developed at the site of his appendectomy. He was able to continue his work. On examination a slightly tender mass was found beneath the scar which measured about 3 by 6 cm. It was not attached to the skin and lay deep in the abdominal muscles. The temperature, pulse rate and leukocyte count were normal. At operation an abscess 2 by 4 cm was found involving the transversalis and internal oblique muscles. The wall of the abscess was about 0.5 cm thick. Several surgical silk stitches were found in the wall of the abscess. The operating surgeon reported that the surgical silk used in the muscle and fascia was size 1. Culture from the wound showed an anaerobic gram-positive bacillus of a type not identified.

NOTE—This patient was operated on after the sketches of the first 4 cases were made.

SUMMARY

Late infection caused by nonabsorbable sutures usually develops slowly. Pain is not severe, and the patient may complain only of discomfort. A firm indurated mass forms beneath the scar of operation, which is usually slightly tender. There may be a slight rise in temperature and leukocyte count. When incised a relatively small abscess is found surrounded by a firm wall of fibrous tissue 1 cm or more in thickness.

Granulomas caused by surgical silk and cotton must be uncommon, since they occurred but four times in several hundred clean operations in the University of Kansas Hospitals Shambaugh¹ recorded 1 case in which a secondary abscess developed after the use of surgical silk five months after complete healing Leithauser² stated that he has abandoned the use of nylon as suture material, since granulomas may form as late as ten months after its use

1 Shambaugh, P Postoperative Wound Complications, Surg, Gynec. & Obst. **64** 765 (April) 1937

2 Leithauser, D J Confinement to Bed for Only Twenty-Four Hours After Operation Arch Surg **47** 203 (Aug) 1943

STRANGULATED INGUINAL HERNIA

Observations in Fifty Cases

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IN THIS article, based on the observations that I have been able to make on the 50 patients with strangulated hernia that came under my care during the past few years, an attempt is made to describe the morbid anatomic evolution of a strangulated hernia. Of these 50 cases, 12 cases are illustrated, as each one of these depicts a phenomenon of certain pathologic significance. An analysis of the important findings, not involving biochemical or bacteriologic investigations, is also included in the article.

The anatomic changes that are brought about as a result of the constriction which gradually leads on to strangulation affect (1) the mesentery, (2) the blood vessels in the mesentery and in the bowel wall and (3) the wall of the intestine itself.

From the observations based on the changes that take place in these three fundamental regions, an attempt is made to illustrate the morbid anatomic processes of the disease and to try and correlate these changes which occur in different parts and also to arrange these in their chronologic sequence.

A study of the illustrations clearly shows that the morbid anatomic changes are not confined to the bowel wall alone but are usually present in the attached mesentery also of the affected loop. In fact, I believe that the changes in the mesentery precede those in the intestinal wall. The illustrations depict (1) the seven stages in the evolution of a strangulated hernia, in their chronologic order, from the stage of mere congestion to one in which the intestinal loop becomes nonviable, (2) the pathologic appearances in the formation of a hematoma, from the stage of dilatation of the veins in the mesentery to the stage when a hematoma may occupy a large portion of the mesentery, and (3) the relation between the changes that take place in the mesentery and the bowel wall.

Thus the following changes are noted. 1. The earliest stage is that in which a normally creamy pink color of the bowel wall, usually the small intestine, changes to one in which it appears flushed (fig 1A).

A part of the paper was read before the staff meeting of the Grant Medical College and Sir Jamsetjee Jejeebhoy Group of hospitals.

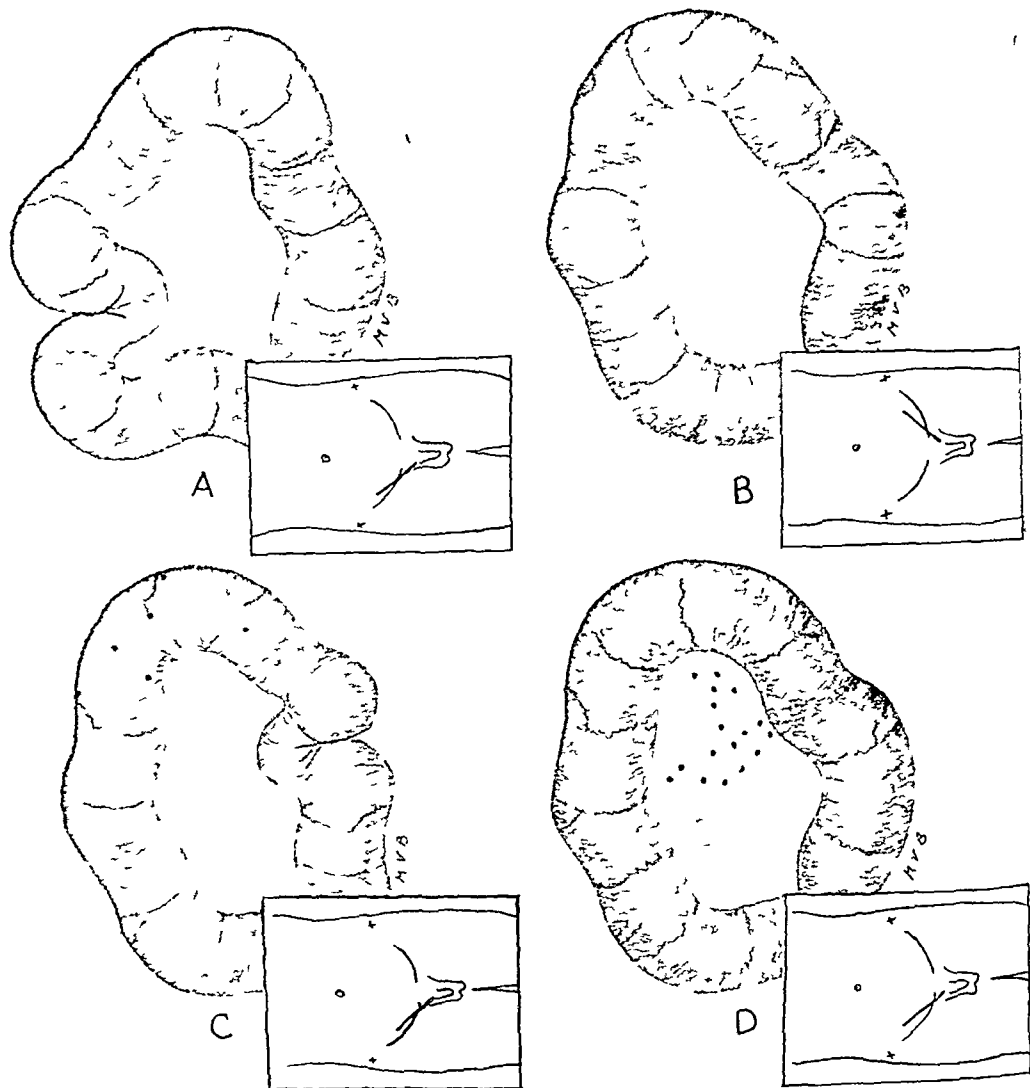


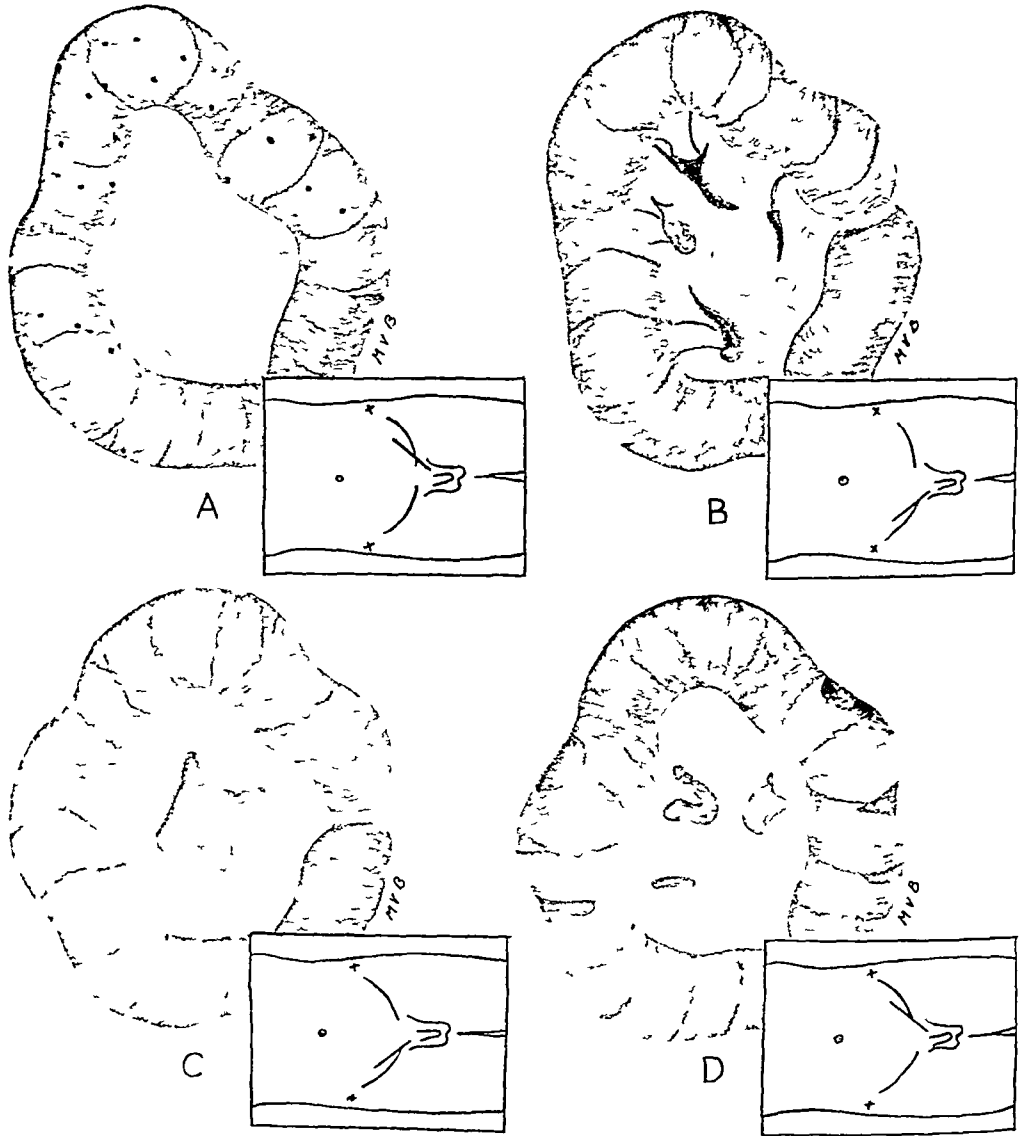
Fig 1—Evolution of strangulated hernia A (case 5633 of 1938), stage 1 A loop of small intestine flushed in appearance is seen. It has lost its usual creamy pink color. The blood vessels coursing on the bowel wall are clearly visible. There is no mark of constriction the site of strangulation B (case 104 of 1940), stage 2 The illustration shows a loop of small intestine which is cyanosed in appearance. The blood vessels on the bowel wall are clearly seen. The mesentery is thickened, and the veins in the mesentery have become visible owing to dilatation. This is the first stage in the formation of a hematoma C (case 5527 of 1938), stage 3 A loop of intestine flushed in appearance. The blood vessels on the bowel wall are clearly visible. A few hemorrhagic spots are seen on the bowel wall D (case 408 of 1939), stage 3 A loop of small intestine. The loop has lost its normal color and appears flushed. The blood vessels on the bowel wall are prominently seen. The mesentery shows a peculiar appearance. It shows numerous dotlike hemorrhagic spots. These dots in the course of time would have gone to form a hematoma. This shows the second stage in the formation of a hematoma the first stage being dilatation of veins as seen in B

2 When the obstruction to the circulation has persisted a little longer, the veins in the mesentery appear dilated and there is thickening of the mesentery, with cyanotic appearance of the bowel wall (fig 1 *B*) 3 When the obstruction has continued a little longer the edema of the mesentery appears to persist, and, in addition, hemorrhagic spots appear either in the bowel wall or in the mesentery, but cyanosis may be absent (fig 1 *C* and *D*) 4 At a later stage the hemorrhagic spots appear in the cyanosed part of the loop (fig 2 *A*) 5 At a still later period, there may be present a central hematoma in the mesentery or small hematomas may appear along the line of the blood vessels in the mesentery The bowel wall corresponding to this portion of the mesentery always shows pathologic changes (fig 2 *B*, *C* and *D*) 6 Still later the cyanosis in the bowel wall becomes more striking, with appearance of blue-black bands along the circumference of the bowel wall in the line of the blood vessels, or the bowel wall may appear brown-mauve-purple or chocolate colored or like wet blotting paper The hematoma in these cases is either large or peripheral (fig 3 *A*, *B* and *C*) 7 When the strangulation has reached its final stage, one finds the typical classical picture, as usually described in the textbooks on surgery, of a nonviable loop of intestine In the particular case illustrated, the mesentery is seen to be almost completely occupied by a large flame-colored hematoma (fig 3 *D*)

It is interesting to observe that in every case the bowel wall that appears affected always corresponds to the portion of the mesentery which is also affected It is noteworthy that the margin of the hematoma and the line of demarcation of the affected and normal parts of the loop always stop short sharply at the line of constriction It is also worth observing that whenever the gray band of constriction was seen in this series of cases it was present on only one limb of the loop

One may therefore conclude that the seven stages in the evolution of a strangulated hernia are (1) the stage of congestion, (2) the stage of cyanosis with edema of the mesentery and visible dilated veins, (3) the stage of appearance of hemorrhagic spots, (4) the stage of cyanosis with hemorrhagic spots, (5) the stage of cyanosis of the bowel wall with a hematoma in the mesentery, (6) the stage of deeper cyanosis with blue-black bands in the wall of the intestine or rough, wet blotting paper appearance with a large or peripheral hematoma in the mesentery and (7) the stage of nonviable loop

The study of several illustrations suggests, as already stated, the working of another interesting pathologic process In all the illustrated cases it will be observed that whatever may be the changes in the bowel wall they are invariably confined only to the part of the intestinal loop whose draining veins, while coursing through the mesentery, have to pass through the area of the mesentery which is occupied by the hema-



(See legend on opposite page)

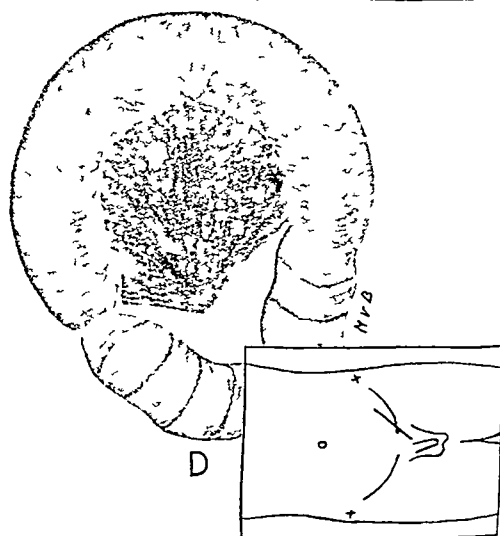
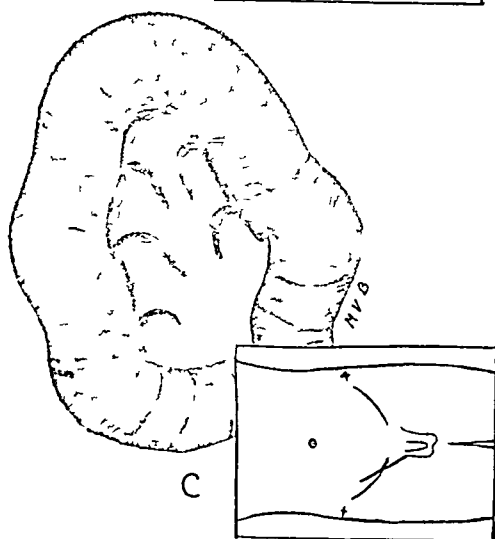
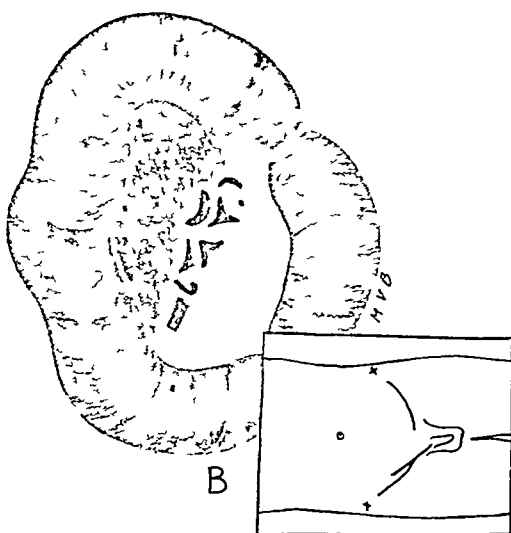
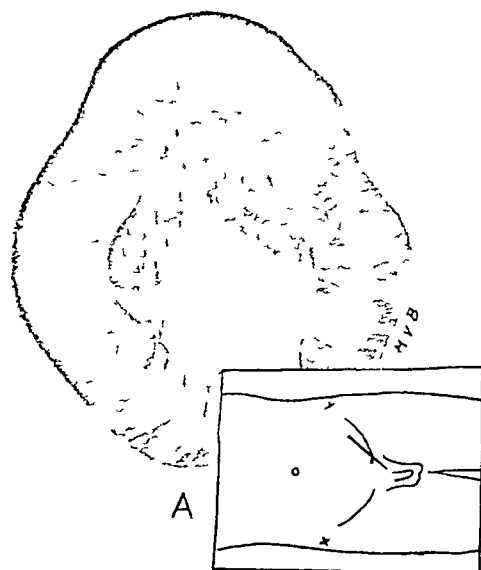
toma The sequence of events is therefore likely to occur in the following order 1 Constriction at the external or internal ring causes obstruction to the venous channels, and dilated veins appear in the mesentery (figs 1 *B* and 2 *A*) 2 Due to overfilling of the veins, there is an exudation of serum into the mesentery, giving rise to edema, which on the operating table is recognizable as thickened mesentery 3 Continuous overfilling and blood stagnation ultimately cause rupture of the wall of the veins, giving rise to hematomas, which in the early period are limited to the line of the blood vessels—the venous channels—and in their extremely early period probably appear like small hemorrhagic spots (figs 1 *D*, and 2 *B*, *C* and *D*) 4 At a later stage the hematomas increase in size and tend to coalesce and form a big hematoma, which then occupies an area varying in size The hematoma causes further pressure on the easily compressible veins and gives rise to thrombosis (fig 3 *A*, *B* and *C*) 5 Once thrombosis has occurred, further deterioration in the condition of the bowel wall is likely to be rapid

Clinically, as a guide to the surgeon while operating on patients with strangulated inguinal hernia, I believe that all cases can be divided into three groups

1 One group consists of cases in which, on opening the sac, only the color of the bowel wall is found to be slightly altered, the bowel being normal in every other way and peristalsis present as in the normal

EXPLANATION OF FIGURE 2

Evolution of strangulated hernia depicted *A* (case 5617 of 1938), stage 4 A cyanosed loop of small intestine The blood vessels are clearly visible on the bowel wall Numerous dotlike hemorrhagic spots are seen on the bowel wall but only on the portion which has a cyanosed color There is no mark of constriction, the site of strangulation *B* (case 95 of 1941), stage 5 A cyanosed loop of intestine The blood vessels are clearly visible on the whole loop On one limb of the loop is a grayish colored band, the site of constriction, showing a constriction and demarcating the normal from the affected part of the loop There is no mark of constriction on the other limb of the loop In the mesentery attached to the cyanosed part of the loop there are several prominent blood vessels—both arteries and veins Toward the visible proximal end of these blood vessels are seen formed four various-shaped small hematomas The rest of the mesentery is normal in appearance This is the third stage in the formation of a hematoma *C* (case 1352 of 1942) stage 5 A loop of small intestine cyanosed in appearance The blood vessels are clearly visible on the whole loop On one limb only of the loop is a grayish colored band the site of constriction and strangulation In the mesentery is seen a central hematoma The veins draining the cyanosed part of the intestine which have to pass through this region, have become dilated because of obstruction and are therefore visible This is the third stage in the formation of a hematoma *D* (case 3130 of 1940) stage 5 A loop of small intestine, parts of which appear cyanosed. On the parts which are cyanosed are seen patches of ecchymosis The blood vessels are clearly visible on the whole loop In the mesentery are scattered hematomas, and the affected part of the intestine corresponds to the site of the hematomas, showing that the cyanosis of the parts of the intestine is likely due to the obstruction of the veins which have to pass through the region of the hematomas This is again the third stage in the formation of a hematoma



(See legend on opposite page)

intestine In such cases the intestinal loops may be immediately and safely returned into the abdominal cavity

2 Another group consists of cases in which there are changes in the bowel wall and/or in the mesentery—changes affecting the color and condition of the bowel wall in varying degree and changes in the mesentery varying from its mere thickening to a large hematoma When the changes are slight, the normal color returns within a short time of relieving the constriction and application of packs of warm isotonic solution of sodium chloride In more advanced cases it may take several minutes before any appreciable change in the color may be detected Also it may take some time for the peristalsis to reappear, but once the peristalsis has definitely begun, no matter what the color, feel or odor of the bowel wall and/or of the mesentery may be, so long as reinduced peristalsis persists and there is no perforation, the loop may confidently be returned to the abdominal cavity In fact I feel that the presence or absence of peristalsis is the only sure token of the viability or non-

EXPLANATION OF FIGURE 3

Evolution of strangulated hernia depicted *A* (case 6339 of 1938), stage 6 A loop of small intestine The loop is reddish brown, chocolate brown or like wet blotting paper It has lost its gloss and sheen and appears mat and sticky The surface is rough The blood vessels are not visible on this affected part of the loop but can be seen on the end of the limbs of the loop The rough appearance is due to wide ecchymosis The mesentery toward its attachment to the affected part of the loop is occupied by a large brownish hematoma, which has acquired the bend of the loop This again shows the effect of the hematoma in producing changes in the bowel wall The rest of the mesentery is normal in color There is no gray band which is suggestive of the site of strangulation *B* (case 811 of 1940), stage 6 A loop of small intestine part of which is deeply cyanosed with blue-black bands at intervals along its circumference in the line of the blood vessels The blood vessels on the affected loop are not visible There is a mark of constriction on one limb only of the loop The mesentery is occupied by a large hematoma, with a few scattered hematomas proximal to the large hematoma In the course of time, if the strangulation had continued these scattered small hematomas would have coalesced with the big hematoma This is the fourth stage in the formation of the hematoma *C* (case 6578 of 1941) stage 6 A loop of small intestine, part of which is deeply cyanosed with blue-black bands along its circumference in the line of the blood vessels The blood vessels are not visible on this part of the loop There is no mark of constriction which is suggested by the appearance of a gray band In the mesentery there is a peripheral hematoma—a hematoma of a linear type along the intestinal attachment of the mesentery There are conical prolongations proximalward into the mesentery from the linear hematoma Dilated veins are visible along these projections from the hematoma This is a hematoma which from its size and shape belongs to the third stage of hematoma formation and fifth stage in the evolution of strangulated hernia, but its peripheral disposition has produced changes of a later stage *D* (case 13 of 1940), stage 7 A loop of small intestine part of which is nonviable This part is rough sticky and blue-black in color It is ununiform in outline and shows complete absence of peristalsis The blood vessels are not at all seen on this part of the loop A mark of constriction as suggested by the presence of a gray band, is seen on one limb only of the loop The mesentery attached to the nonviable part of the loop is occupied by a large flame-colored hematoma This is the final or seventh stage in the evolution of a strangulated hernia and the final or fifth stage in the formation of a hematoma

viability of the bowel wall and that it is the only sure criterion as to whether the intestines should be returned into the peritoneal cavity

3 In the third group are included the cases of strangulation in which the loop does not regain its peristaltic power and must therefore be considered as nonviable, even if the color and other changes are not those typical of a nonviable loop. In such cases the appropriate surgical procedure must be carried out.

All the 50 patients were operated on under spinal anesthesia, it being induced in some with 12 to 15 cc of 5 per cent stovaine and in others with 10 cc of procaine hydrochloride dissolved in the patient's cerebrospinal fluid. After the operation, all patients complained of difficulty in passing urine for a period varying from twenty-four to seventy-two hours after the operation, and all had to be catheterized.

All patients were men.

The ages of the patients varied from 20 to 82 years. The largest number of cases (26) occurred between the ages of 31 and 50 years.

TABLE 1—*Age Groups of Patients with Strangulated Inguinal Hernia*

Age Yr	Number	Per Cent
Below 21	1	2
21-30	11	22
31-40	14	28
41-50	12	24
51-60	8	16
Above 60	4	8

There was only 1 patient below 21 years. Table 1 gives the different age groups.

All the hernias were of the indirect inguinal type, and the majority of these (29, or 58 per cent) were of the right side. There were no cases of bilateral strangulation.

Of the 50 cases, in 44 cases the hernial sac contained fluid, in 4 cases there was no fluid and in 2 cases it was not recorded. Of the 44 cases, in 20 cases the fluid was of the serous type while in 24 cases the fluid was definitely sanguinous in nature.

In the majority of the cases (36, or 72 per cent) the sac contained loops of small intestine, it contained omentum alone in 3 cases, omentum and small intestine in 7 and large intestine in 2. In 2 of the cases the contents could not be identified with certainty, as the hernia was spontaneously reduced before the operation but after the spinal anesthesia was given. Table 2 gives the comparative figures.

Of the 50 patients, 5, i. e., 10 per cent, died before their discharge from the hospital. Postmortem examination was not available in any of the 5 cases. One patient, the patient who was 82 years old, died

suddenly on the eighth day after the operation, the clinical diagnosis given being coronary thrombosis. One patient, in whom the resection of the nonviable loop with drainage through Paul's tubes was done, died within twenty-four hours after the second operation of end to end anastomosis, from continuously increasing abdominal distention. The second operation was done eleven days after the first operation. One patient died within a few hours of the operation. Two patients died two and four days after the operation. Both had nonviable loops of small intestine, and in both patients excision of the loops with drainage through Paul's tubes was done. It was observed during their postoperative life that there was an enormous quantity of greenish fluid which drained from Paul's tubes.

When the patient who died of coronary thrombosis is excluded, one can therefore say that only 4 patients died of strangulated inguinal hernia, a mortality rate of 8 per cent.

TABLE 2—*Comparison of Contents in Hernial Sac*

	Present Series Approximate per Cent	Mangot, R. Post Graduate Surgery London Butterworth & Company, 1926 vol 1 p 1037 Approximate per Cent	Frankau C Brit J Surg 19 176 1931 Approximate per Cent
Small intestine alone or with omentum	86	83	75
Large intestine	4	6	5
Omentum alone	7	8	6.2

Of the 50 cases, in only 4 cases there was not a history of hernia. In these 4 cases, i. e., 8 per cent, the first appearance of the hernia was manifested by the advent of strangulation. In 3 other cases a complete history is not recorded, 8 patients had hernia of less than one year's duration, 11 patients had hernia for a period varying from one to three years and 7 patients from three to five years, while 17 patients had hernia of more than five years' duration. Of the 17 cases, the hernias in 4 cases were of a recurrent type.

One patient had an unusual postoperative complication. During the operation, after the strangulation was relieved and the intestines were being returned into the abdominal cavity, the patient passed a large hemorrhagic stool and suddenly collapsed, with stoppage of respiration and loss of consciousness. Artificial respiration was immediately started and nikethamide given intravenously. While artificial respiration was being given, one of the lower ribs on the left side was accidentally fractured. Another injection of nikethamide was given, by the intracardiac route. Artificial respiration had to be continued for three quarters of an hour, the patient remaining unconscious all that time. He then

TABLE 3—*Review of Cases of Strangulated Inguinal Hernia from 1938 to 1942*

Ref. No.	Name	Age Yr.	Duration	History of Hernia	Signs and Symptoms	Site	Nature of Hernia	Contents of the Sac	Comment
1938									
227 (fig. 1 C)	B. A.	45	6 days	A few months	1 Vomiting for the past few days	Right	Large amount of serous fluid	The loop of bowel showed a few subserous hemorrhagic spots	Apex of the sac was adherent to the top of the testicle, numerous thick adhesions, obstruction on the same side some months previously
291 (death)	M. D. S.	82	2 hr.	6 mo.	1 Patient looked extremely ill	Right	No fluid	Not noted	Three attacks of irreducibility in the last 6 mo. patient suddenly collapsed and died on the 8th day of operation. Hernia operation done on the left side in 1919
307 (fig. 2 I)	G. V.	48	7 hr.	1 yr.	1 General condition good 2 Pulse slow but feeble 3 Painful inguinal swelling	Left	1 Air amount of brownish fluid	Part of the loop was cyanosed in color and this showed numerous points of subserous hemorrhages dilated veins in the mesentery	Three attacks of irreducibility
333 (fig. 1 I)	S. J.	55	6 hr.	20 yr.	1 General condition good	Right	1 Air amount of brownish fluid	Two short congested loops of small intestine	1 Immediately after reducing the bowel the patient passed a large foul smelling stool collapsed and became unconscious artificial respiration was done during which 1 lower left rib was fractured 2 Unconscious for ¾ hr 3 1 or 10 days after operation he was mentally abnormal then gradually recovered 4 Attacks of irreducibility twice during the last 6 mo.
348	D. S.	60	1 day	5 mo.	1 Vomited 3 times 2 Painful swelling	Right	1 Air amount of yellowish fluid	Loop of small intestine	
359 (fig. 3 A)	G. S. P.	30	8 hr.	1 yr.	1 General condition good	Left	Small quantity of sanguinous fluid	1 Color of the obstructed loop cyanosed mauve purple like wet blotting paper 2 Ectchymosis in the mesentery near its attachment to the bowel	
366	I. L.	60	3 hr.	About 1 yr.	1 General condition good	Right	No fluid in sac	1 Small mass of omentum 2 No bowel	Sac was particularly thin and friable
49 (Duke's Memorial Hospital)	D. P. B.	73	6 hr.	10 yr. recurrence	1 General condition good 2 No vomiting 3 Painful inguinal swelling	Right	1 Air amount of serous fluid	1 One loop of small intestine 2 One loop of large intestinal cecum	Sliding hernia. Patient was operated on for strangulated right inguinal hernia 10 yr. ago during the last 10 yr. he has had several attacks of irreducibility lasting for 1 hr. or so

1939

403 (fig 1 D)	M H	20	3 hr	7 yr	1	Right	Small amount of serous fluid	Two loops, each about 1 ft in length, with a large area of mesen- tery drawn in, part of the mesentery was edematous and on both sides there were hemor- rhagic spots	An attack of irreducibility 2 yr ago but reduced
1 S	M H	10	8 hr	6 mo	1 General condition good 2 No vomiting 3 Pain in the abdomen	Left	Small amount of sanguinous fluid	One small loop of bowel cyanosed in color 1 linear mark on 1 limb at the site of constriction	
1711 (death)	M W	54	1 days	6 yr	1 General condition bad 2 Vomiting almost every hour for 2 days 3 Absolute constipation 4 Tongue dry 5 Ittecup 6 Painful inguinal swelling	Left	Small amount of sanguinous fluid	1 About 1 foot length of small intestine cyanosed in color and no peristalsis even after bath in hot isotonic solution of sodium chloride 2 A mass of gangrenous omentum	1 After ligation of mesenteric vessels, gangrenous loop of intestine was excised, 2 Paul's tubes were tied into the 2 limbs, 6 days later another surgeon did end to end anastomosis within 24 hr the patient had disten- tion and died 2 Gangrenous mass of omentum was also excised
201	M R	32	1 day		General condition good	Left	Small amount of sanguinous fluid	Two loops of congested and cyanosed intestine, each about 9 in long, mesentery of the two loops was thick and discolored	Hernia developed while patient had a severe cough
404	A W S	50	21 days	3 mo	1 General condition good 2 No vomiting 3 Tense painful swelling	Right	Small amount of sanguinous fluid	One loop of congested bowel	Appendix was removed
471	I M	40	1 days	10 yr	1 General condition good 2 Constipation 4 days 3 No vomiting	Right	Fair amount of sanguinous fluid	Sac contained cecum and appendix	
617 (death)	D G	18	6 hr	1 yr	1 General condition bad 2 Vomited 2 times 3 Tense painful swelling 4 Tongue dry 5 Patient perspired profusely	Left	Fair amount of sanguinous fluid	Two ft. of small intestine 18 in., nonviable 1 Color was dark blue violet 2 Bowel had lost its sheen 3 Loop felt sticky and heavy 4 Small 5 Complete absence of peristalsis 1 Loop of small intestine	After ligation of the mesenteric vessels, the nonviable loop was excised 2 Paul's tubes were tied in the 2 limbs patient died on the 1th day
11	H A	60	2 hr	20 yr	1 Painful inguinal swelling 2 No vomiting, but tongue dry	Right	No fluid in the sac		Irreducible since 9 p m on 12/18/39 it was reduced by taxis became irre- ducible again on 12/20/39 and was oper- ated on immediately, the hernia had 3 sacs—the outer 2 of fibrous tissue and the innermost of peritoneum the mid- dle sac had developed yellowish mucoid cysts in its wall
11	I N	40	5 hr	2 yr	1 General condition good 2 Vomited once tongue dry and coated 3 Complete constipation	Right	No fluid in the sac	One loop of normal small intestine	
722 (death)	R M	11	1 day	Several months	1 General condition bad 2 Vomited once 3 Complete constipation 4 Semiconscious	Left	Sac contained several ounces of turbid dirty yellowish fluid	Sac contained a short loop of small intestine, mesenterically atonic, with its intestinal attachment was edematous, grayish green translucent type of edema	normal " Patient died soon after operation

TABLE 3—*Review of Cases of Strangulated Inguinal Hernia from 1938 to 1942—Continued*

Ref. No.	Name	Age yr.	Duration	History of Hernia	Signs and Symptoms	Side	Nature of Fluid	Contents of the Sac	Comment
							1940		
11 (death, fig 3 B)	A R R	45	2 days	5 yr	1 Frequent vomiting 2 Absolute constipation for 2 days 3 Pain in umbilical region	Left	Small amount of sanguinous fluid	1 A large mass of brownish black omentum About 9 in. of nonviable loop of small intestine	All tissues at site of obstruction were flabby and friable a lateral anasto- mosis was done and nonviable portion excised wound was drained, patient died 48 hr later
101	H H Y	50	9 hr	2½ mo	1 No vomiting 2 Painful tense swelling,	Left	Fair amount of serosanguin- ous fluid	1 A large mass of almost black omentum 2 A cyanosed loop of small intestine about 6 in. long	The omental mass was excised
104 (fig 1 B)	K I	30	27 hr	Since childhood	1 Vomited 10 to 11 times 2 Constipation 3 Tense tender swelling 4 Good general condition	Left	Small amount of sanguinous fluid	A short cyanosed loop of small intestine	
111	J A	40	8 hr	6 yr	1 Pain in the epigastrium 2 No vomiting	Right	Fair amount of sanguinous fluid	About 1 foot of small intestine mucoid type of edema in the mesentery along its line of attach- ment to the intestine	1 Patient passed a large hemorrhagic stool immediately after operation 2 The right testicle was big, 2½ in. in diameter
112	S P	55	Not noted	20 yr	1 Painful swelling 2 Vomiting 3 Constipation 4 Good general condition	Left	Fair amount of sanguinous fluid	Sac contained 2 loops of small intestine 1 One loop cyanosed, had a conical diverticulum and patches of hemorrhage in the mesen- tery 2 One loop pale yellow gray the 2 limbs almost adherent to each other and anchored to the sac by means of a band	Both loops recovered color with bath of hot isotonic solution of sodium chloride 4 days later pneumonia developed but patient gradually recov- ered hernia gradually increasing in size for past 20 yr
811 (fig 3 B)	J K	60	8 hr	5 yr	1 No vomiting 2 Good general condition	Right	Small amount of light brown fluid	1 A loop of small intestine of about 30 in. of which 9 in. was dark violet with blue-black bands a large hematoma in the mesentery	
892	M J	60	10 hr	Not noted	1 Tense tender swelling 2 No vomiting	Right	No fluid	2 Contents of sac could not be identified	1 After spinal injection the hernia reduced spontaneously
1555	D D K	45	8 hr	6 yr	1 Vomited once	Right	Fair amount of dirty straw colored fluid	Sac contained 2 loops 1 One loop of intestine had mucoid edema in the mesentery along its intestinal attachment 2 One loop had a patch of dis- coloration at its antimesenteric border	Hemorrhagic stool 3 hr after operation

1205	P P	60	Not noted	Not noted	1 Patient was admitted in a semiconscious condition he is deaf 2 Simple comminuted fracture of both calcaneal and second lumbar vertebrae	Right	Small amount of serous fluid	1 Normal loop of bowel 2 Mesentery showed pronounced thickening and extremely dilated veins
2255	S B	35	1 day	2 yr	1 Tense, tender, painful swelling 2 Constipation but vomited twice	Right	Small amount of sanguinous fluid	1 One ft of congested small intestine rough on the surface like wet blotting paper Loops of small intestine
2290	S I	24	Not noted	1 yr	1 Painful tense swelling, 2 No constipation 3 No vomiting	Left	Little serous fluid	
2420 (fig 2 D)	B M	20	8 hr	No hernia previously	1 Vomited several times and constipated	Left	No fluid	Loop of bowel showed patches of cyanosis and subserous hemorrhages, mesentery was edematous and contained patches of hemorrhages
3183	R D	70	1½ hr	Not noted	1 Vomiting 2 Constipation	Right	Fair amount of sanguinous fluid	About 3 ft of small intestine
3184	H S R	43	10 hr	Several years recurrence	1 Painful swelling in the left inguinal region 2 No vomiting	Left	Fair amount of serosanguinous fluid	Small intestinal loops
3603	M A	60	6 hr	1 yr	1 Painful swelling 2 No vomiting	Right	Fair amount of sanguinous fluid	The mesentery along the intestinal attachment at 1 place was reddish and cyanosed, and at corresponding 1 or 2 places at antimesenteric border the bowel had striations of cyanosis and of ecchymosis
3775	S A H	65	4 hr	4 yr	Painful inguinal swelling	Left	Small amount of serous fluid	The sac contained a large mass of omentum, in 1 place the vessels in the omentum were thrombosed and there was a small hematoma
3760	R K	45	2 days	4 mo recurrence	1 Vomited 3 times 2 Constipated for 2 days 3 Painful tense swelling	Right	Small amount of serosanguinous fluid	Two ft of small intestine, part of it cyanosed, mesentery of this loop was thickened and had hemorrhages in parts the loop showed a line of previous anastomosis, the suture line below, continued into the mesentery, this line was more congested than the rest of the bowel
								Two days after operation patient showed signs of pneumonia but recovered
								At administration of spinal anesthesia the hernia reduced, operation was, however, done and the loop brought out for inspection
								Operated on 6 to 10 yr previously for bilateral hernia

TABLE 3—*Review of Cases of Strangulated Inguinal Hernia from 1938 to 1942—Continued*

Case No	Name	Age, yr	Duration	History of Hernia	Signs and Symptoms	Side	Nature of Fluid	Contents of the Sac	Comment
1940—Continued									
101	B B	38	12 hr	2 yr	1 No vomiting, 2 Tongue coated 3 Constipated 4 Painful inguinal swelling	Left	Serous fluid	Contents of the sac could not be identified	Hernia reduced of its own accord just before operation. Particular loop could not be identified as the one which was strangulated
1016	S S	20	1 hr	6 yr	1 Vomited twice 2 Painful inguinal swelling	Right	Large quantity of serous fluid	Sac contained 2 ft of small intestines; mesentery was thickened and edematous and 2 enlarged lymphatic glands were palpable	
1941									
1012	A B	40	12 hr	2 yr	General condition good no vomiting	Left	Large amount of dark colored fluid	1 One small loop was dilated and had lost sheen and was grayish black 2 One loop normal in color	Five previous attacks of irreducibility on primary side to side isoperistaltic anastomoses was done and the non-viable loop excised
1014	P A G	20	18 hr	None	1 Draining sensation around the umbilicus 2 Vomited several times during the night 3 Passed one stool	Right	Small amount of serous fluid	Dilated short loop of small intestine	While sac was being opened the contents of the loop was slightly nicked. Injury buried with a purse string suture while patient was trying to lift a heavy weight. His foot slipped and for the first time a swelling appeared in the right inguinal region and became irreducible
1081	S G	50	4 hr	15 yr	1 No vomiting 2 Painful inguinal swelling	Right	Fair amount of fluid	Sac contained 2 loops 1 1½ ft long, a small area in this loop bluish in color and no peristalsis 2 2 ft long, this loop showed dilated vessels and thickened and edematous mesentery	
4416	M Y	25	3 hr	5 yr	1 Vomited 4 times in 3 hr	Left	Small amount of serous fluid	1 Large mass of blue omentum 2 One loop of small intestine 9 in long, with a thickened mesentery with 2 small spots of hemorrhage 3 One congested small loop 9 in long	Bladder was adherent to the outer surface of the medial side of the sac

C117	K K	40	1 day	6 yr	Nothing particular	Left	Small amount of serous fluid	Three loops of small intestine total length about 3 ft	
C381	B I	29	6 hr	3 yr	1 Vomited 3 times 2 Tender inguinal swelling	Right	Small amount of straw colored fluid	One short loop of small intestine	
C277	P I	45	3 hr	None	1 Pain in the abdomen 2 Painful swelling in inguinal region	Left	Small amount of straw colored fluid	1 Large mass of omentum and 2 short loops of small intestine, each about 9 in long	While patient was lifting weight a swelling suddenly appeared in the inguinal region, which could not be reduced, no history of hernia
C278 (M, 7 O)	B A M	28	1 day	Since childhood	1 Patient looked ill 2 Vomited twice 3 Painful inguinal swelling	Right	Little fluid, straw colored	Small loop of bowel part of it had bluish black stripes loop was enveloped in a mass of bluish black omentum, this mass of omentum was everted	
C55 (Theodor Memorial Hospital) (M & B)	K S I	55	10 hr	23 yr recurrence	1 Painful swelling in the right inguinal region 2 No vomiting 3 Patient looked ill	Right	Large amount of serous fluid	1 A small tag of omentum 2 Two long loops of small intestine 1 of the loops was purplish and the mesentery attached to this part had a few areas of hematomas of various shapes and sizes near its attachment to the intestine	During the latter part of the operation the patient collapsed, but he recovered
1942									
C131 (M, 2 O)	M II	40	1 day	2 yr	1 First vomiting, constipation and hiccup 2 Swelling, appeared suddenly on straining and became irreducible	Right	1 Air amount of sanguinous fluid	One short loop about 9 in of small intestine with ecchymosis 1 small hematoma on 1 side of the mesentery away from its site of attachment to the bowel	
C400	M S	40	1 days	2 yr	1 General condition good 2 Tense but not tender inguinal swelling	Right	Large amount of serosanguinous fluid	Large mass of omentum and 18 in of congested small intestine	
C401	I I	40	3 hr	1 yr	1 Vomited 1 time and had 6 watery stools 2 Tense painful inguinal swelling 3 Patient looked ill and so not inclined to talk	Right	1 Air amount of serous fluid	Large length of everted loop of small intestine and a large hematoma adherent to the mesentery which could be detached	
C402	B A	40	3 days	3 yr	1 No vomiting or pain 2 Tense painful inguinal swelling 3 General condition good	Left	Small amount of serous fluid	Large mass of edematous omentum	

gradually regained consciousness and the power of respiration. For ten days after the operation the patient was restless, irrelevant in speech and behavior and mentally generally deranged. From the eleventh day he gradually recovered, and he was discharged in a normal mental condition after a few days. When he was mentally normal, careful inquiry revealed that the patient remembered nothing that occurred during the abnormal period.

In 1 case the contents of the sac were of an unusual type—one loop had a short conical diverticulum. This loop was congested and cyanosed in color, with a hematoma in the mesentery. The second loop was cream gray in color, with a rough sticky surface. The bowel wall felt thickened and almost solid and was rough and cold to touch. It had lost all its gloss and sheen.

A brief description of the operation which I have uniformly adopted in this series of cases is as follows:

An incision is made beginning at a point above the level of the surface marking of the internal abdominal ring. It is extended obliquely downward and medially to a level about 1 inch (2.5 cm) below the pubic tubercle, i. e., well on to the scrotal swelling. The incision is then deepened to expose the external oblique aponeurosis in the upper and lateral part of the wound and the sac in the lower and medial part of the wound. A nick is now made in the external oblique aponeurosis, proximal to the external abdominal ring. The sac is then carefully lifted up, i. e., pinched up with two pairs of tooth forceps and incised between the two. The incision is then lengthened and the fluid in the sac allowed to drain out. The strangulated loops of intestine are then drawn out of the sac into the wound. These are now held by an assistant and covered by a pack with hot isotonic solution of sodium chloride. After these are thus secured, and only after, the incision in the external oblique aponeurosis is extended and the constriction divided. Such a procedure is adopted to avoid the possibility of the intestine's slipping into the abdominal cavity on sudden release of the constriction. The intestinal loops are now pulled out to examine the site of constriction on the bowel wall and the condition of the intra-abdominal portion of the intestines for a few inches beyond the site of strangulation. The necessary manipulation is then done and the loops returned into the abdominal cavity. The sac is now dissected bluntly up to its neck and ligatured at this point with a transfixion suture of surgical gut. The portion of the sac distal to the ligature is excised. No repair of the canal is done and tightening of the internal abdominal ring is not attempted. The external oblique aponeurosis is now sutured with a continuous surgical gut suture and the skin with interrupted silk or silkworm gut sutures. In the postoperative treatment, stress is laid on giving the patient plenty of fluids. In addition to what he takes by

the mouth, he is given at least 2 pints (1 1 liter) of isotonic solution of sodium chloride or 5 per cent dextrose in isotonic solution of sodium chloride by the rectum every day for three consecutive days

SUMMARY

1 Changes that take place in the mesentery, the blood vessels and the bowel wall are described

2 From the observations based on these changes, it is suggested that there are probably seven stages in the evolution of a strangulated inguinal hernia. These stages are illustrated

3 The stages in the formation of a hematoma in the mesentery and the probable sequence of changes consequent on its formation are suggested

4 It is suggested that on the operating table these cases may profitably be divided into three groups—the first two including cases of the viable intestine and the third group including cases of the nonviable intestine

5 An analysis of my 50 cases is made, all the important and interesting features being noted

6 A brief description of the operation as routinely adopted by me is given

The surgeons of the Sir Jamsetjee Jejeebhoy Hospital allowed me to operate on their patients with strangulated hernia. The superintendent of the Sir Jamsetjee Jejeebhoy group of hospitals allowed me access to the case records and permitted me to publish the cases. Mr S. Deshpabhu gave advice in the preparation of the illustrations

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GASTRIC ULCERS PRODUCED EXPERIMENTALLY BY VASCULAR LIGATION

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VIRCHOW'S hypothesis¹ that human gastric ulcers were vascular in origin led to several attempts to reproduce similar lesions in animals by ligation of the gastric vessels. For the most part no significant results were obtained. Dogs were generally used, and short of total interference with the blood supply ligation had no effect on the intactness of the stomach.² This was largely due to a highly efficient collateral circulation. There is a complete circle of anastomoses around the two curvatures of the canine stomach,³ and when the main arteries are tied the blood flow through intercommunicating branches is sufficient to maintain the nutrition of the organ. In human beings⁴ the anatomic arrangement of the blood supply of the stomach is practically the same as that in dogs. Recently, Somervell⁵ tied the gastric arteries in a

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1 Virchow, R. Historisches, Kritisches und Positives zur Lehre der Unterleibsaffektionen, *Arch f path Anat* **5** 362-364, 1853.

2 (a) Babkin, B. P., Armour, J. C., and Webster, D. R. Restoration of the Functional Capacity of the Stomach When Deprived of Its Main Arterial Blood Supply, *Canad M A J* **48** 1-10, 1943. (b) Bernheim, B. M. Partial and Total Devascularization of the Stomach, *Ann Surg* **96** 179-183, 1932. (c) Laine, J. A., and Bergh, G. S. The Effect of Ligation of Arteries of the Stomach upon Acid Gastric Secretion and upon the Endoscopic Appearance of the Gastric Mucosa in the Dog, *Surgery* **13** 136-144, 1943. (d) Litthauer, M. Experimentelle Untersuchungen zur Pathogenese des runden Magengeschwurs, *Virchows Arch f path Anat* **195** 317-341, 1909. (e) Graulich, R. Etudes sur la pathogenie de l'ulcus gastrique, *Rev belge sc med* **11** 93-103, 1939.

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4 Berlet, K. Ueber die Arterien des menschlichen Magens und ihre Beziehungen zur Aetiologie und Pathogenese der Magengeschwurs, *Frankfurt Ztschr f Path* **30** 472-489, 1924. Hofmann, L., and Nather, K. Zur Anatomie der Magenarterien, *Arch f klin Chir* **115** 650-671, 1921. Reeves, T. B. A Study of the Arteries Supplying the Stomach and Duodenum and Their Relation to Ulcer in Collected Papers of the Mayo Clinic, Philadelphia, W. B. Saunders Company, 1919, vol 11, pp 3-22.

5 Somervell, T. H. Physiological Gastrectomy. The Operation of Ligation of the Arteries of the Stomach to Relieve Hyperacidity and to Prevent Recurrent Ulceration After Gastroenterostomy, *Brit J Surg* **33** 146-152, 1945.

large series of cases of duodenal ulcer, and no complications referable to the operation developed. A few experiments with ligation in rabbits were reported by Omata⁶ and Graulich,^{2e} with conflicting results. Since in all the species used previously the main gastric vessels were directly continuous with one another and thus provided the stomach with a rich collateral circulation, it was deemed worth while to observe the effects of ligation on the rat's stomach, which has a different type of blood supply.

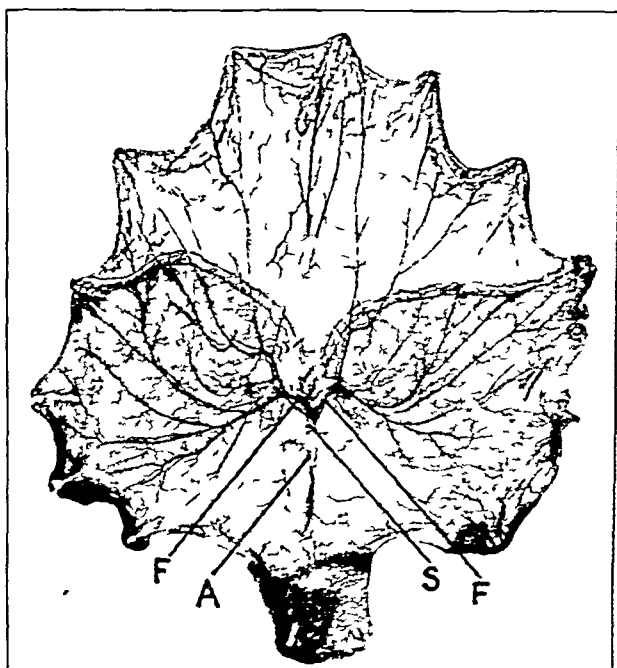


Fig 1—Injected and cleared normal specimen showing the blood supply of the rat's stomach. The three main branches arise from a common stem at *S* and are ligated close to their origin. The two fundic branches (*FF*) are longer and wider than the single antral vessel (*A*), which is barely visible. Arteries and arterioles are accompanied with veins and venules. The fundus is more vascular than the antrum or the rumen. $\times 2$

BLOOD SUPPLY OF THE RAT'S STOMACH

The rat's stomach⁸ is divided by a transverse ridge into two parts, a nonsecretory rumen, or forestomach, and a glandular region, that is subdivided into an acid and enzyme-secreting fundus and a mucus-

6 Omata, T. Experimentelle Studien über die Entstehung des runden Magengeschwurs. Virchows Arch f path Anat **269** 797-802 1928

7 Berg, B. N. Vascular Changes in the Mucosa in Experimental Nutritional Gastritis. Gastroenterology **7** 340-354 1946

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secreting antrum (fig 4) The main blood supply is derived from an artery which divides just below the junction of the esophagus with the stomach into three branches (fig 1) Two of the vessels run on opposite sides of the organ, giving off several long branches to the fundus and rumen and a few short ones to the antrum The third, shorter and thinner than the others, runs along the lesser curvature, sending small dichotomous twigs to the antrum and ending a little above the pylorus The greater curvature receives short branches from a vessel in the

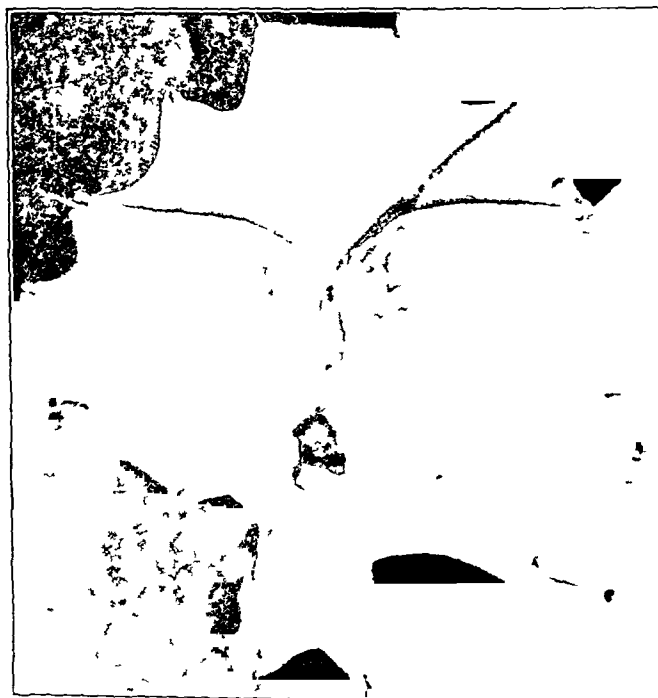


FIG. 2—Antral ulcer twenty four hours after ligation of the antral vessels. The stomach is opened along the greater curvature and is fixed in a 4 per cent solution of formaldehyde $\times 2$

omentum which continues upward from the duodenum. Arteries and arterioles are accompanied with veins and venules.

Direct communication between the main gastric vessels, characteristic of human beings and dogs, is absent in rats. In the latter, the vessels terminate separately and connections between them are made through small branches in the submucosa and the capillary networks in the different layers of the wall of the stomach. The capillary plexuses in the mucosa of the fundus are more abundant than those in the mucosa of

the antrum or rumen and contribute to the greater vascularity of this part of the stomach.

The observations herein reported are limited to the antrum and fundus; there is no counterpart of the rumen in the human stomach.

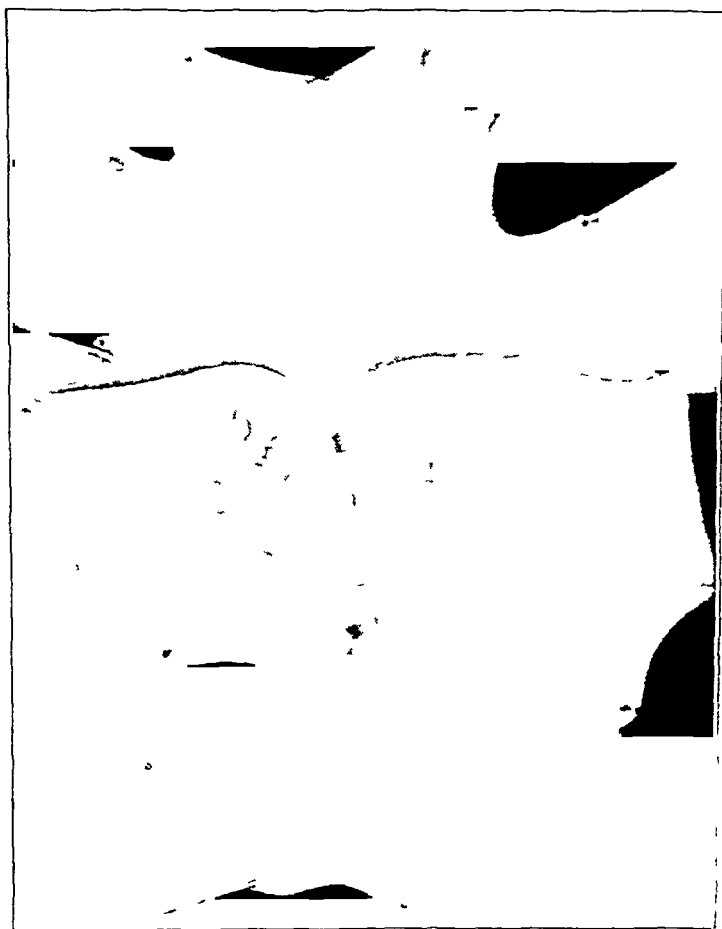


Fig 3—Healing antral ulcer sixteen days after ligation. A zone of hyperemia surrounds the remaining defect. Fixation was done in a 4 per cent solution of formaldehyde $\times 2$

TECHNIC

Fifty-four albino rats of both sexes, ranging in age from 85 to 417 days, were used, and three types of experiments were performed. In group 1 the single artery supplying the antrum was tied, in group 2 the blood supply of one half of the fundus was interrupted, and in group 3 bilateral ligation of the fundic vessels was done. In each instance the accompanying vein was included with the artery and the vessels were cut between ligatures close to their origin from the main stem. All the operations were performed with the animals under ether.

anesthesia, and the stomach was mobilized through an incision in the upper mid line. The animals were killed with ether twenty to twenty-four hours after ligation of the antral vessels and twenty-four or forty-eight hours after the fundic blood supply was cut off. The stomach was removed immediately, opened along the greater curvature and stretched with pins on a piece of cardboard. After being washed in isotonic solution of sodium chloride the specimen was fixed in a 4 per cent solution of formaldehyde. Several rats in groups 1 and 2 were

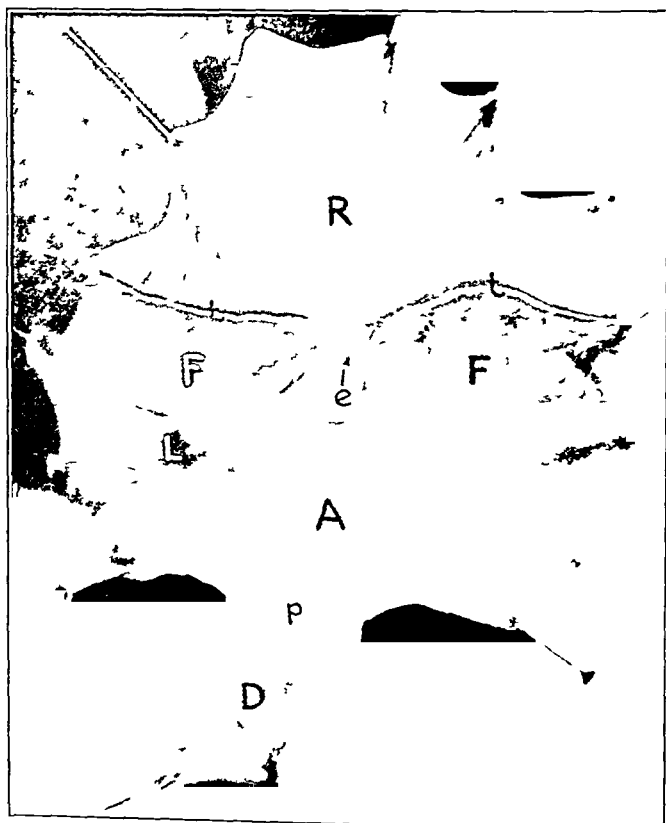


Fig 4—Fundic ulcer (*L*) twenty four hours after unilateral ligation of fundic vessels. The differentiation of the glandular area into a fundus (*FF*) and antrum (*A*), which becomes indistinct after fixation is shown clearly in this fresh specimen. The rumen or forestomach (*R*) lies above the transverse ridge (*tt*), and the esophageal opening is at (*e*). The duodenum (*D*) begins at the pylorus (*p*) $\times 2$

examined eight days and sixteen days respectively after operation. In 9 animals, the gastric vessels were injected with india ink and the stomach was cleared in methyl salicylate after passage through graded alcohols according to a technic described elsewhere.

RESULTS

Group 1—Ligation of the Antral Blood Supply' The wall of the antrum was pale and edematous, and the swollen surface was devoid of its usual covering of mucus. In 10 out of 18 rats there was a single, punched-out, penetrating ulcer about 5 mm in diameter situated in the center of the antrum (fig 2). The defects had rounded margins and were oval, triangular, stellate or semilunar in shape. In several instances



Fig 5—Symmetric, sharply defined infarcts in the fundus twenty-four hours following bilateral ligation of the fundic vessels. The necrotic mucosa is still in situ, and after it separates an ulcer remains. $\times 2$

only the serosa remained in the base and perforations were found twice. Blood clots were often present in the craters. Multiple small irregular superficial ulcerations of the mucosa were observed in 5 animals, and in 3 no grossly visible defects were noted.

Two rats examined after eight days had ulcers showing signs of repair. In 1 the ulcer was reduced to a small defect surrounded by a zone of intense hyperemia (fig 3), in the other there was still a con-

siderable crater but the margins were puckered. Of 2 animals after sixteen days there was a minute, irregular, superficial defect in 1 and a rather large, shallow lesion in the other.

Group 2—Unilateral Ligation of the Fundic Vessels. In contrast with the pallor of the antral mucosa after ligation, the surface of the fundus was intensely congested and had a deep, purplish red color. In this series 12 rats were examined after twenty-four hours and 8 after

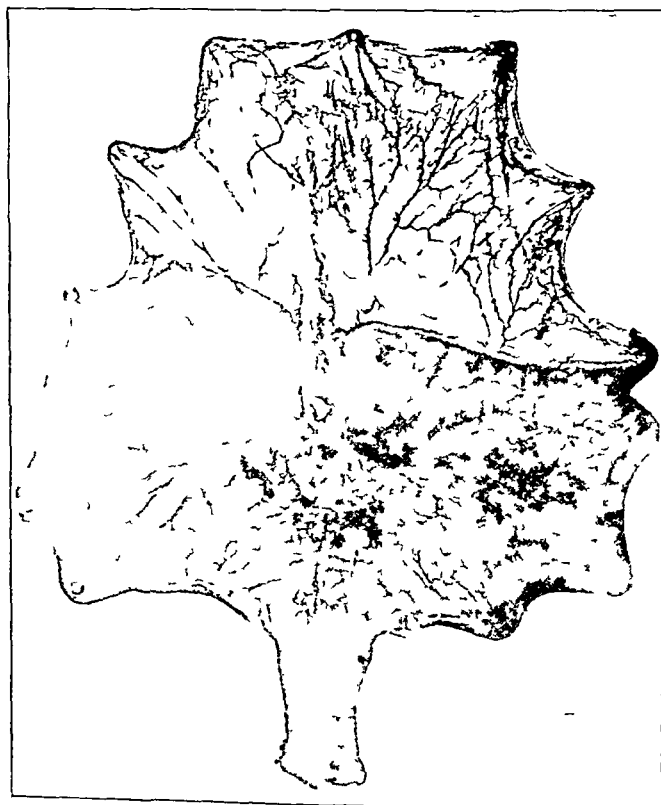


Fig 6—Antral ulcer surrounded by collateral vessels in an injected and cleared specimen. Compare with the less vascular normal antrum in figure 1 \times 2.

forty-eight hours. In only 1 animal did there develop an ulcer, which consisted in a large shallow, triangular-shaped defect (fig 4).

Group 3—Bilateral Ligation of the Fundic Vessels. The mucosa had a mottled appearance consisting of purplish red and reddish brown blotches. Five out of 8 animals killed after twenty-four hours had multiple ulcers in both halves of the fundus. The lesions varied considerably in size and shape: irregular deep fissures or larger stellate

defects were usually present, but in one experiment there were two extensive infarcts with necrotic mucosa still in situ (fig 5) The latter finding was a good example of the changes antecedent to ulcer formation After separation of the slough the remaining defect constitutes an ulcer None of the lesions were perforated In 2 rats multiple, minute, superficial healing ulcerations were found after eight days, and in 2 others the mucosa was normal after sixteen days

COMMENT

The frequent occurrence of gastric lesions after vascular ligation in rats is in striking contrast with the normal results obtained in other species This is probably due in large part to anatomic differences in the blood supply of the stomach In rats the main gastric vessels arise from a common stem and do not communicate directly with one another as they do in dogs and in human beings, instead they end separately, and anastomoses are made through terminal branches The central part of the antrum is supplied by a single artery and vein, and when these vessels are tied a collateral circulation must be established through long, narrow anastomotic channels which are distant from secondary sources of blood supply (fig 6) The fact that centrally located ulcers develop in a large number of animals shows that the collateral circulation is inadequate to keep the antral wall intact The periphery of the antrum is preserved, however by short branches from adjacent vessels along the fundic border and the greater curvature

Since the fundus is more vascular than the antrum and has a better collateral circulation, it is not surprising that fundic ulceration is uncommon after unilateral ligation Injected specimens show that an adequate flow of blood is provided through short anastomoses with branches of the intact fundic vessels of the opposite side, with branches of the vessels along the greater curvature and with antral twigs When bilateral ligation is performed, however, the fundus loses most of its blood supply and ulcers appear Collateral channels are reduced to intercommunications with vessels along the greater curvature and with antral branches, and these are insufficient to maintain the nutrition of the tissues

It is noteworthy that despite extensive gastric ulcerations all the rats kept for periods of eight days or sixteen days survived ligation Various stages of repair were observed, but healing was more advanced in fundic lesions than in antral lesions The difference in rate of healing was probably attributable to the more rapid establishment of a collateral circulation in the fundus than of that in the antrum

For many years the term "peptic" has been applied to ulcerations of the stomach in human beings This connotation implies that peptic enzymes can digest living gastric mucosa but there is no clinical or

experimental evidence to warrant this assumption. Certainly there is nothing in the present experiments on ligation to support the idea that enzyme action is related to the formation of ulcers. The experimental lesions are simply infarcts (fig 5), and the size and depth of the defects left after separation of the dead tissue are determined by the effectiveness of the collateral circulation.

Previous studies⁹ have shown that mucosal changes similar to those found in human antral gastritis develop in rats on a low calcium diet. However, further experiments¹⁰ designed to induce deeper penetration of the antral wall by prolongation of the period of calcium deficiency have been unsuccessful, the defects become larger and the surrounding epithelial hyperplasia becomes greater, but the craters do not extend beyond the muscularis mucosae. These findings seem to indicate that a separate factor is concerned with involvement of the muscular coats after the initial break in the mucosa has taken place. Another possibility is that penetrating lesions are not preceded by a mucosal defect but are caused by a single factor which simultaneously affects all the layers of the gastric wall. An example of such a mechanism is provided by the experiments on ligation herein reported.

CONCLUSION

Owing to the anatomic arrangement of the blood supply of the rat's stomach, it is possible in this species to produce ulcers in the antrum and in the fundus by ligation separately of the vessels supplying these areas.

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53 529

TUBERCULOUS DACTYLITIS IN THE ADULT

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TUBERCULOUS dactylitis in the adult is generally uncommon and its appearance rather rare. Although the practicing orthopedist and the busy pathologist can recall having seen a case or two of the condition in the adult, the literature, especially in North America, contains only scattered reports of cases. Furthermore, our conception of this lesion as described in the textbooks and more important works on tuberculosis is that of tuberculous dactylitis in childhood.

Tuberculous dactylitis or spina ventosa is usually a disease of infancy and childhood. Herzfeld and Tod¹ found 97 cases of the condition in 1,403 tuberculous children, thus representing 6 per cent of all cases of surgical tuberculosis. Sorrel and Sorrel-Dejerine,² in a larger sampling, reported an incidence of 14 per cent. In both series the disease became increasingly uncommon after 5 and scarce after 10 years of age.

No statistics on the incidence of adult spina ventosa were found. Stenstrom,³ of Sweden, in 1935 reported 3 cases of tuberculosis in the phalanges of adults, for the purpose of describing differences between spina ventosa in the child and that in the adult. Isolated reports of cases from Germany,⁴ France,⁵ England⁶ and Italy⁷

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1 Herzfeld, G., and Tod, M. C. Tuberculous Dactylitis in Infancy, *Arch Dis Childhood* 1: 295, 1926.

2 Sorrel, E., and Sorrel-Dejerine. Tuberculose osseuse et osteo-articulaire, Paris: Masson & Cie 1932, pp. 2-21.

3 Stenström, B. Phalangeal Tuberculosis in Older Persons, *Acta radiol* 16: 471, 1935.

4 Oehlecker cited by Stenström.³ Schinz cited by Stenström.³

(For reprints, write Dr. A. L. Umansky.)

imply the infrequent appearance of the lesion. In Christopher's textbook on "Minor Surgery"⁸ there is an excellent photograph of the condition, reproduced through the courtesy of Dr M L Mason, but no reference to a report by him.

The case presented herewith is of threefold interest. First, it demonstrates some of the differences between the lesion in the adult and that in the child. Second, it presents a problem in differential diagnosis. When the patient entered the Mount Sinai Hospital with an obvious pathologic fracture of the left index finger, he did not state the fact that he had been observed for several months in the Metropolitan Hospital Out-Patient Department, where many roentgenograms were taken. He did state, however, that he had been discharged from the Navy because a roentgenogram had shown a "tumor of the finger." Thus when roentgenograms were taken at Mount Sinai Hospital, because of the advanced stage of the disease, the lesion was interpreted as being the result of a tumor, syphilis or tuberculosis. A biopsy specimen suggested the latter. A few weeks later, after he had left the hospital, his past history was reinvestigated, and five old roentgenograms were found, thus the third interesting aspect, the fact that all the roentgenograms serially delineate the natural course of the disease from the initial to the final stage.

REPORT OF A CASE

History—S C, a 19 year old Negro factory worker, was admitted to the Metropolitan Hospital on March 30, 1941 with the history of a sudden attack of dizziness, weakness, pain in the right side of the chest and temperature up to 103 F. Physical signs and subsequent roentgenograms of the chest were indicative of a hydropneumothorax on the right side with partial collapse of the lung. In frequent aspirations large amounts of slightly turbid fluid were removed from the chest, which were on several occasions found to be positive for acid-fast bacilli. Inoculation tests on guinea pigs gave negative results however as did also examinations of sputum and gastric aspiration. After a slow and prolonged course he was discharged in an improved condition on Dec 22, 1941 and referred to the outpatient department for continued study.

During the next few months, while being observed in the outpatient department a painless progressive swelling of the proximal portion of the left index

5 Carpenter C and Hayem A. Tuberculous Osteoarthritis of the Index Finger in an Adult. *Prat med franç* 1 1165 1921-1922. Rieunau G. Tuberculosis of the Phalanges. *Paris med* 2 287, 1933.

6 Heath P M. Case of Tuberculous Dactylitis, *Proc Roy Soc Med (Sect Surg)* 14 170 1920-1921.

7 Antonoli G M. Autoplastic Bone Graft in the Treatment of Spinal Ventosa. *Boll e mem Soc piemontese di chir* 5 1180, 1935.

8 Christopher I. *Minor Surgery*, ed 4. Philadelphia W B Saunders Company, 1940 p 648.

finger was noted, and on May 23, 1942, in addition to the periodic roentgenograms of the chest a roentgenogram was taken of the left hand (fig 1), which revealed an elevation of the periosteum along the proximal half or the shaft of the proximal phalanx of the left index finger. There was indefinite cortical irregularity, especially at the radial aspect of the bone, and concomitant swelling of the surrounding soft tissue. Serologic studies and serial roentgenograms were suggested to determine the etiologic factor. In subsequent months of study reactions to frequent Wassermann tests were negative and periodic examinations of sputum gave normal results. Roentgenograms of the chest demonstrated no changes in the pulmonary fields.

On Sept 18, 1943, because the patient began for the first time to experience pain in the left index finger a second roentgenogram was taken (fig 2)

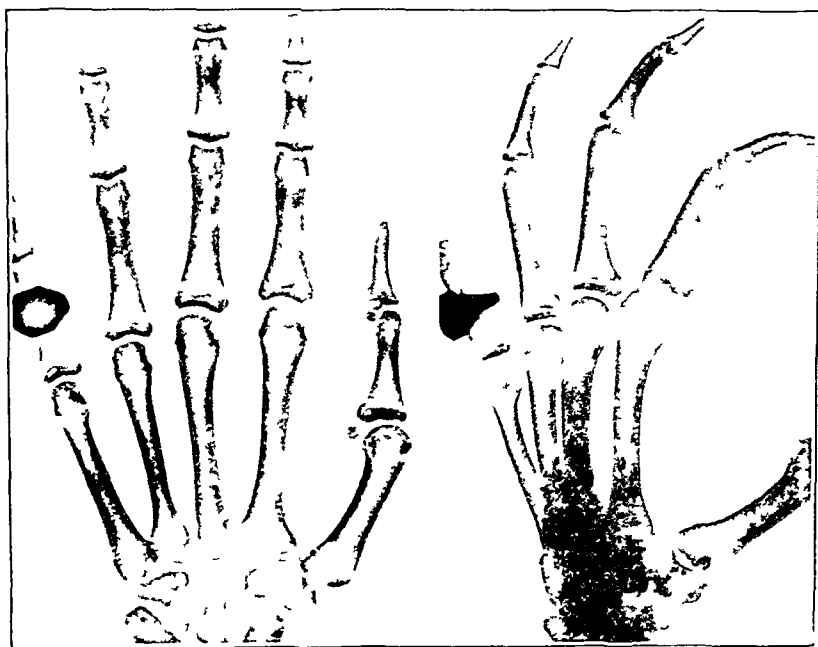


Fig 1—On May 23, 1942 there was elevation of the periosteum along the proximal half of the diaphysis of the proximal phalanx of the left index finger. The shaft was apparently uninvolved.

There was now revealed a large area of rarefaction involving the proximal half of the shaft extending into the base and resulting in a moderate expansion of the bone. There was some sclerosis of the trabeculae in the distal half of the shaft, almost obliterating the cancellous portion of the bone but not extending into the head. The cortex of the volar surface of the involved portion of the phalanx appeared to be absent. A considerable increase in the swelling of the soft tissues had also taken place.

Two weeks after his last visit to the outpatient department he injured his left hand and he was admitted to the Metropolitan Hospital for the second time on Oct 4, 1943. The left index finger presented a marked swelling at

its base greatest toward the radial side. The swelling was hard and indolent and appeared to be fixed to the underlying bone. There was tenderness to palpation only over the dorsum of the finger. A roentgenogram (fig 3) showed considerable thickening of the distal two thirds of the proximal phalanx, with distinct cortical irregularity throughout the involved area and sclerosis in the



Fig 2—On Sept 16 1943 a large area of rarefaction in the shaft had replaced the periostitis and had resulted in moderate expansion. The remainder of the shaft showed sclerosis of the trabeculae almost obliterating the cancellous portion of the bone. There was partial destruction of the cortex.



Fig 3—On Oct 4 1943 there was considerable thickening of the distal two thirds of shaft with distinct cortical irregularity, and sclerosis had taken place. The proximal third showed irregular areas of decreased density with a pathologic fracture through it.

distal half of the shaft. The proximal third showed irregular areas of decreased density. An irregular transverse fracture was present through the center of the destructive area which now extended into the base of the phalanx. Slight

ventral displacement of the distal fragment and anterior angulation at the site of fracture were noted. The swelling of the soft tissues had increased slightly. A punch biopsy of the lesion yielded insufficient diagnostic evidence, and the patient was discharged from the hospital.

He was seen again in the outpatient department on Nov. 23, 1943, where another roentgenogram was taken (fig. 4). This roentgenogram showed further destruction of the phalanx. The fracture was not healed, but the fragments were in good alignment. There was no change in the swelling of the soft tissues.

A few weeks later he entered the Navy, had roentgenograms of the chest and passed the physical examination. The swelling and disability, however, prevented full use of the finger, and he was discharged after one month. He returned



Fig. 4—On Nov. 23, 1943 further destruction and loss of bone substance at the fracture line were noted. The ever present soft tissue swelling is shown clearly in this figure.

to the outpatient department for the last time on Feb. 1, 1944, where roentgenologic examination of the left hand (fig. 5) showed the previously noted destructive lesion of the proximal phalanx with widening of the shaft. There was formation of new bone in the involved portion of the shaft and base as well as bony callus at the dorsolateral aspect of the site of fracture and still considerable irregularity of the adjacent ends of the fracture where union had not occurred.

He was able to work in a factory and was asymptomatic until April 12, 1944, when he entered the Mount Sinai Hospital with a five day history of severe pain in the left index finger following a fight in which he struck his adversary on the head with his left hand.

Examination—The patient was a well developed muscular Negro complaining of pain in his left index finger. Significant physical findings were confined to

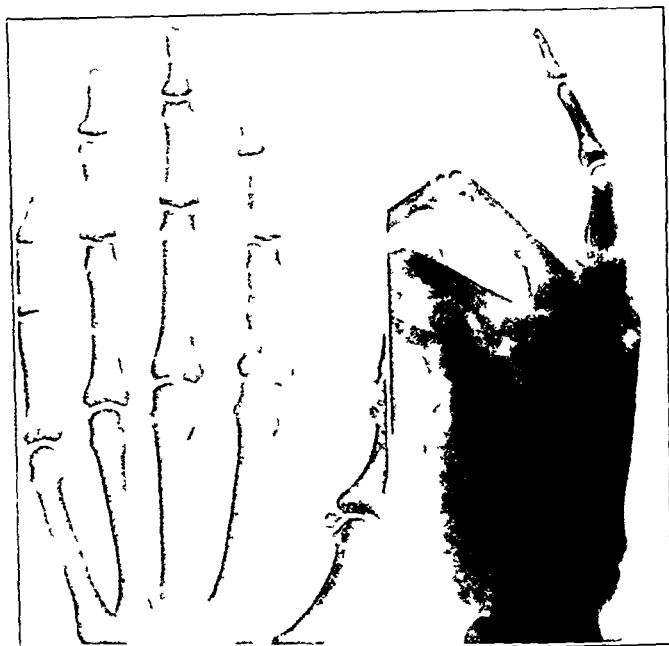


Fig 5—On Feb 1 1944 destruction of the phalanx was continuing, but there was some evidence of formation of new bone and callus



Fig 6—On April 12 1944 there was increased extensive destruction with bony debris extending out into the soft tissues and a widened sclerotic shaft. The medullary cavity is almost completely obliterated

the left hand, where the index finger presented a bony, hard, fusiform swelling of the proximal phalanx, greatest toward the radial side. Crepitus could be elicited over the midportion of the swelling, and there was moderate tenderness at this site.

Laboratory Data—Examination of the blood revealed a hemoglobin content of 108 per cent, 10,600 leukocytes and a normal differential cell count. A Wassermann test elicited a negative reaction, the erythrocyte sedimentation time was normal. The urine showed a faint trace of albumin. Roentgenologic examination of the chest showed no abnormality in the lungs. Both costophrenic sinuses were obliterated by adhesions. Examination of the left hand showed a pathologic fracture through the base of the proximal phalanx of the index finger, at which site there was evidence of an extensive destructive process. Bony debris extended out into the soft tissues, which showed considerable swelling. The shaft was widened and sclerotic, and the medullary canal was almost completely obliterated (fig. 6).

A biopsy was performed, and a considerable amount of loose, ragged bone was encountered at the site of the fracture. This was curetted out, and much white tissue having the appearance of a tumor was obtained. Microscopic examination revealed a granulomatous and necrotizing osteitis with extensive necrosis, but no acid-fast bacilli were found.

Operation—A racquet-shaped incision was made completely encircling the base of the left index finger and extending proximally on the dorsoradial surface of the second metacarpal for half its length. The superficial tissues were incised in a circumferential fashion. The extensor and flexor tendons were then transected and allowed to retract back. Next, the metacarpal was exposed and its head and neck resected obliquely from the first to the second web space to eliminate the protrusion of this portion of bone. The entire finger and head of the metacarpal were then removed. Flaps were mobilized and the skin closed.

Pathologic Report (Dr. Paul Klemperer)—The specimen was a left index finger resected through the metacarpal bone. The proximal part of the first phalanx and the adjacent tissue were replaced by a large amount of grayish, necrotic material, giving the digit a spindle shape, the typical appearance of a *spina ventosa*.

Histologic examination showed diffuse granulation tissue with scattered areas of coagulation necrosis, which infiltrated the periosteum and the adjacent soft tissues. It included many epithelioid cell tubercles with typical Langhans giant cells. The same process extended into the bone and between the often irregular bone trabeculae, frequent tubercles were seen and but little normal fat marrow, substituted for the most part by the tuberculous granulation tissue. The pathologic diagnosis was tuberculous osteomyelitis and periostitis and *spina ventosa*.

Postoperative Course—The wound healed by primary union, and recovery was entirely uneventful.

Follow-Up—For one year after operation the patient worked as a plasterer, without difficulty, and there was a good functional and cosmetic result. There are no systemic or further osseous manifestations of tuberculosis.

COMMENT

The various roentgenographic changes seen in tuberculous dactylitis are portrayed in many books and articles and the subject is adequately

discussed, that is, for the childhood form Sorrel and Sorrel-Dejerine² present serial roentgenograms depicting the evolution of this form. For the adult type, however, only casual references⁹ to differences are made or a single roentgenogram is shown of one phase of the picture and taken to represent the entire pattern of change.

The earliest roentgenologic evidence of involvement of the bone in both the childhood and the adult form of the disease is elevation of the periosteum (fig 1). This elevation, at first the result of an underlying serous effusion,¹⁰ is indicated by a linear deposit of new bone surrounding part or all of the diaphysis. At this time or shortly after, changes in the cortex may be represented by an indefinite irregularity. Although at first there is usually no evident swelling of the soft tissues, this soon occurs and progressively increases as the disease process advances.

In the child the periosteal reaction is intense, and increase in thickness and expansion of the cortex result. This may be so distinct that the normal shaft may be seen within the expanded periosteal sheath of new bone.^{9a} Gradually, however, destruction of the shaft occurs, and it separates as a sequestrum. The sequestrum shows progressive fragmentation, and much of the internal contents of the involucrum are absorbed, leaving a cystlike cavity which appears to be ballooned or injected with air, the so-called spina ventosa, and restoration of bone is gradual. Often, however, the sequestrums begin to suppurate, and within this pus the new periosteum necroses. At this stage fistulas exist, through which small fragments of the sequestrum are extruded. The disease may advance and destroy the neighboring joint.

Now these changes and the greater incidence in childhood, especially in the infant, may be explained in part by certain anatomic facts. Primary tuberculosis of the bone shows predilection for well vascularized bone. In the child there is a large artery in the diaphysis of the short tubular bones, which favors lodgment of infectious material, and these bones still contain spongy bone instead of a marrow cavity until the fourth or fifth year of life. Also, the periosteum has a

9 (a) Brailsford J F. *The Radiology of Bones and Joints*, ed 3, Baltimore, Williams & Wilkins Company, 1945, pp 28-29 and 38-39. (b) Hodges, P C, Phemister D B and Brunschwig A. *The Roentgen-Ray Diagnosis of Diseases of Bones*. New York: Thomas Nelson & Sons, 1938, p 400. (c) Sorrel and Sorrel-Dejerine.²

10 Golding F C. *Tuberculosis of Bone*. In Shanks S C, Kerley, P, and Turing E W. *A Textbook of X-Ray Diagnosis*, London: H K Lewis & Co, 1939, vol 3, pp 414-415.

regenerative power of reaction which is lacking in adult life.² In the adult the initial periostitis is replaced by a large area of rarefaction, and the finer cancellous structure and the compact cortex are absorbed leaving a coarser cancellous model of the bone which shows a moderate expansion (fig 2). The cortex may be partly eroded or destroyed and there may be sclerosis of the trabeculae in the adjacent portion of the shaft with a tendency to obliteration of the cancellous bone. The cortical irregularity and sclerosis increase as the bone thickens, while the coarse, cancellous, irregularly destroyed area progresses and may appear honeycombed. At this stage pathologic fracture is most likely and appears to be somewhat common (fig 3). With further destruction, delayed healing and continued trauma, there appears a decidedly rarefied zone, giving the appearance of loss of bone substance as in cases of nonunion (fig 4). In a later stage callus formation occurs, and there are manifestations of formation of new bone (fig 5). In the final phase there is, however, increased, extensive destruction of bone, and this debris may be seen extending out into the soft tissue (fig 6). The remainder of the shaft is widened and sclerotic, and the medullary cavity is almost completely obliterated but there is no large sequestrum, no involucrum and no fistula formation. It may be that these last changes are inevitable, but in this case and in those reported ablation of the finger precluded their appearance.

Since tuberculous dactylitis in the adult is rarely seen, diagnostic criteria without biopsy are difficult to establish and several simulating lesions require differentiation. Syphilitic dactylitis is probably the most difficult lesion to be excluded. Here, however, more than one finger may be involved. Roentgenograms show distinct periostitis, and the bone is increased in breadth principally by the deposition of subperiosteal new bone with but little influence from expansion. There is greater density to the bone and less evidence of necrosis. Evidence of syphilis elsewhere (especially periostitis of the long bones) and response to antisyphilitic therapy are conclusive.

The phalanges are a favorite site for the occurrence of enchondromas. The central type of solitary enchondroma may be a problem when there is present expansion of the phalanx consisting in a translucent area with trabeculation surrounded by a sclerotic bony capsule.¹⁰ But there is no periostitis and the cortex is attenuated. The tissue is generally devoid of calcium but contains irregular nuclei or islands of calcium throughout, which are indicative of the chondromatous nature of the tumor.¹¹

The development of osteitis in the phalanx of a young adult, in the absence of obvious infectious or traumatic causation, with a woolly out-

line of reacting periosteum^{9a} or the striking destruction and fragmentation of bone as seen in the end stage of tuberculous dactylitis may give rise to the suspicion of sarcoma. The localization and monostosis of the former and metastasizing feature of the latter are valuable diagnostic aids.

The lesions of the bone in Boeck's sarcoid are not always punched out and cystic in nature.¹¹ It has been pointed out¹² that these lesions may begin merely as a coarsening of the trabecular pattern, after which areas of both cortical and central destruction appear, and as the disease progresses the destruction may be extensive. This pattern is exceptional, however, and typically one sees a multiplicity of small cystic areas situated centrally in the ends of the phalanges.

In coccidioidomycosis bony lesions are usually multiple, involve cancellous bone and often are associated with destruction of bone and formation of new bone, but the solitary lesion is practically indistinguishable from tuberculosis.¹³ In fact, giant cells and caseation occur, and only the finding of the double-contoured spherules makes the diagnosis. The report of a case of the condition in a phalanx is illustrative.¹⁴ The history of infection in an endemic area and positive reactions to a coccidioidin test of the skin and complement fixation test are highly suggestive of coccidioidomycosis.

Leprosy and yaws in nonendemic areas may be mistaken for tuberculous and syphilitic dactylitis. Predominant cancellous dissolution and difference in localization in giant cell tumors and solitary bone cysts are of differential diagnostic value. Osteomyelitis of a phalanx would be most unusual and might be accompanied with clinical signs of sepsis, sequestration and later pyogenic arthritis.

Aside from the roentgenographic differences between the childhood and adult forms of tuberculous dactylitis, others are manifest. The frequency of fistula formation in the child contrasts sharply with its absence in the adult and has already been mentioned. As in this case, 1 of the 3 patients in the cases Stenstrom³ reported displayed a pathologic fracture. Pathologic fractures in tuberculosis of the bones and joints are unusual. This is perhaps because in advanced tuberculosis of the long bones with involvement of the adjacent joint either the patient is

11 Holt J F and Hodges F J. Significant Skeletal Irregularities of the Hands. *Radiology* **44** 23, 1945.

12 Doub H P and Menagh F R. Bone Lesions in Sarcoid. A Roentgen and Clinical Study. *Am J Roentgenol* **21** 149, 1929.

13 Carter, R A. Infectious Granulomas of Bones and Joints with Special Reference to Coccidioidal Granuloma, *Radiology* **23** 1-16, 1934. Smith C E. Parallelism of Coccidioidal and Tuberculous Infections, *ibid* **38** 643, 1942.

14 Goren M L. Localized Coccidioidomycosis of Bone. Report of a Case. *J Bone Joint Surg* **28** 157, 1946.

bedridden or the part is protected by a cast or appliance. In tuberculous dactylitis of childhood these fractures are not seen, probably because there is much formation of new bone. In fact, with the exception of tuberculous dactylitis (and tuberculosis of the metacarpals and metatarsals), this degree of periosteal reaction and thickening of the bone is not observed in osseous tuberculosis¹⁵. In the adult form, on the other hand, the predominant feature is osteitis with destruction, and, with easy accessibility of the part to trauma, fracture of the bone is enhanced. In some of the cases seen by Kohlmann¹⁶ there was so much bone destruction that the phalanges were broken up into fragments.

The tuberculous child is usually hospitalized because of pulmonary lesions or generalized tuberculosis, and thus dactylitis frequently is an incidental finding of a generalized process. By the same token, multiple lesions are not uncommon. Contrariwise, in the adult dactylitis is not part of a generalized process, and multiple lesions are usually not found.

Clinically, there are no reports of shortening or contracture of the involved finger in the adult. This deformity, however, is often present in the child, especially during the healing stage¹⁷. Two factors may be responsible for this change: first, disturbance in growth resulting from destruction of the epiphyseal plate of the involved phalanx and second, the pull of the tendons of the finger imposed on the contracting granulation tissue¹⁸.

Finally, the treatment of the two forms of dactylitis appears to be different. It is felt that the outlook in the childhood type is good and that with the usual immobilization treatment and general antituberculous therapy many lesions will spontaneously heal¹⁹. In cases in which operation has been indicated, good results have been reported with subperiosteal resection and curettage²⁰ followed in some cases by bone grafts²¹. In the stage of sequestration, sequestrectomy is the

15 Webster, R. Tuberculous Dactylitis. *M. J. Australia* 2: 55, 1938.

16 Kohlmann, cited by Stenstrom³.

17 Mercer, W. *Orthopaedic Surgery*, ed. 3. Baltimore, Williams & Wilkins Company, 1943, pp. 299-301.

18 Kaufmann, E. *Pathology*, translated by S. P. Reimann. Philadelphia: P. Blakiston's Son & Co., 1929, vol. 2.

19 Dalto, A. Spina Ventosa Cured in an 18 Months Old Child. *Prensa medica* 42: 2012, 1941. Nesti, D. Conservative Treatment of Tuberculosis of the Bone, *Policlinico (sez. prat.)* 40: 431, 1933. Mercer¹⁷.

20 Roger, J. P. A Case of Spina Ventosa. *Bull. Soc. med. d. hop. Univ. de Quebec* 35: 181, 1934. Herzfeld and Todd¹.

21 Fontaine, R. Double Spina Ventosa Metacarpal and Metatarsal Treated by Extirpation of the Lesions and Resection of the Diaphysis Followed by Osseous Grafts. *Rev. de chir. Paris* 75: 639, 1937. Antonelli¹.

method of choice² In the adult form of dactylitis the therapeutic armamentarium is limited It might be supposed, in the absence of precedent, that immobilization of the finger and general measures are worthy of trial However, tuberculosis of bone in which the disease involves or threatens the adjacent joint in the adult is, in general, regarded as more dangerous than that in the child, and immobilization becomes synonymous with fusion Now, since the finger does not lend itself easily to such a procedure, eradication by means of ablation becomes a definitive step Furthermore, the liability of recurrent fracture, with its consequent impairment of function of the finger and the decidedly destructive nature of the lesion, makes amputation proximal to the metacarpophalangeal joint a somewhat beneficent eventuality

METHOD OF CORRECTION OF ECTOPIA CORDIS

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DEFFECTS of the sternum are not common. They may vary from simple notching of the manubrium and irregularities in shape of the xiphoid to complete absence of the entire structure.

The minor defects are not usually recognized and are discovered incidental to a roentgenogram of the chest. The larger defects are brought to attention at birth, because of their effects on the thoracic and mediastinal contents. These effects may be varied, depending on the extent of the defect. Herniation of the lungs will cause decided disturbances of respiration. Lack of normal restraint of the heart and associated large vessels may cause profound circulatory phenomena. This last type of defect attracted my interest, and in studying the literature I was impressed by two facts, namely, (1) the high mortality rate and (2) the attitude of hopelessness on the part of surgical attendants in discussing such cases.

With these facts in mind, an intensive study was made in an effort to correct some of these defects. This study led my associates and me to believe that most of these patients could be benefited if they were properly prepared and the operation done in stages. I should like to report 2 cases of ectopia cordis and offer a method that I used in both cases.

REPORT OF CASES

CASE 1—J. S., a white boy aged 7 weeks, entered the hospital on Jan. 14, 1943. The chief complaint was paroxysmal attacks or rapid heart beat accompanied with cyanosis.

Physical Examination—The head and scalp were normal. There was bulging of the anterior surface of the neck between the two sternocleidomastoid muscles. This became larger at times. In the chest anteriorly the ribs did not meet in the midline, and there was an absence of the entire manubrium and the body of the sternum. Only a thin layer of skin lay over the defect, and with each pulsation of the heart the cardiac structures raised the skin above the level of the thoracic wall. When this act took place, the large vessels leading from the heart could be seen. The lower end of the sternum showed the xiphoid present. The abdomen was normal.

The probable diagnosis was a congenital defect of the sternum with partial ectopia cordis.

The child was placed under an oxygen tent temporarily, and during the next week a formula was supervised, with definite improvement of the child. During

the second week the oxygen tent was removed, but the child continued to have paroxysms of cyanosis and difficulty in breathing.

Röntgenograms were made showing the defect. Consultants of the general surgical service were of the opinion that no surgical therapy was indicated. Because of the unusual type of case it was decided that the child would not get better and that it was worth trying some procedure in an endeavor to relieve the acute situation.

On Feb. 11, 1943, with the patient under nitrous oxide and ether anesthetic, an incision was made on the right side of the lower part of the chest. A block of

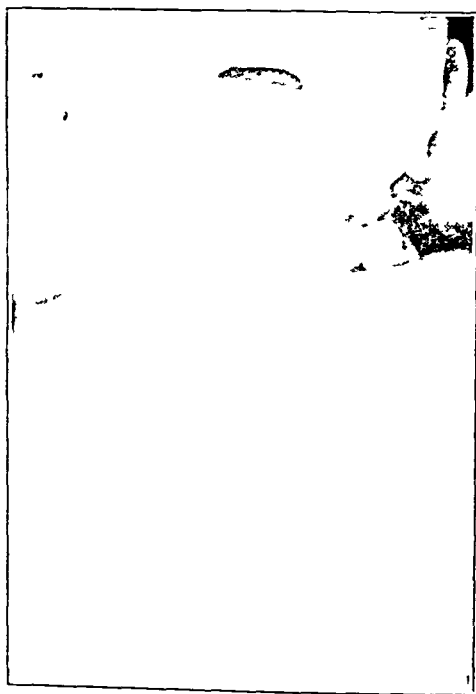


Fig. 1 (Case 1).—Patient aged 7 weeks. Anterior view showing defect of the sternum.

cartilage which included the eighth and ninth costal cartilages, measuring $1\frac{1}{2}$ inches (3.8 cm.) in diameter was removed en masse. About twenty-five minutes as required for this procedure. The child's pulse became somewhat irregular. It was decided to close the wound. The cartilage was placed in plasma and refrigerated. The wound healed by primary union.

On Feb. 18, 1943, with the patient again under anesthesia induced with nitrous oxide and ether the anterior part of the chest was prepared and with Dr. Rix placed the heart in the thoracic cavity by direct pressure a 4 inch (10 cm.) transverse incision was made across the midportion of the hiatus. By sharp dissection the cardiac structures were dissected loose from their attachment to the sternum and surrounding cervical muscles. There was no definite pericardium. The sternum was then placed back into the thoracic cavity. The soft structures

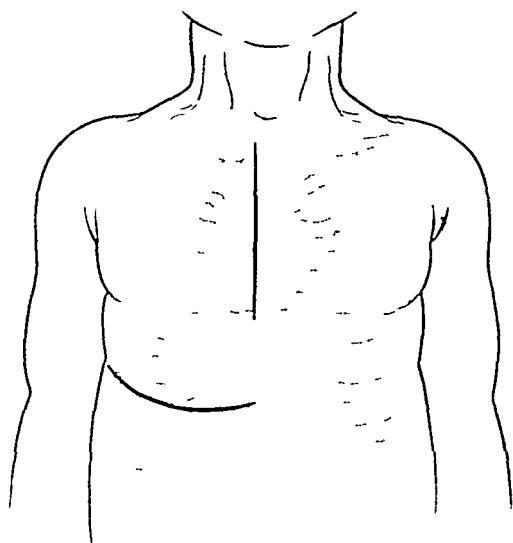


Fig 2—Diagram outlining location and types of incision

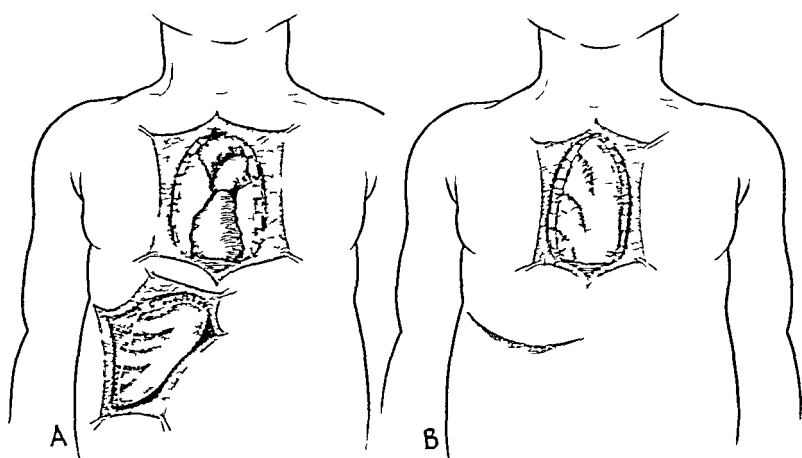


Fig 3—*A*, diagram showing exposure of the sternal defect and outlining of the massive graft of cartilage to be removed. *B*, diagram showing graft wired in position.

were then mobilized. The piece of cartilage previously removed and preserved in the plasma was laid across the hiatus, and two silver wire sutures were placed through the costal cartilages pulling the lateral sides of the opening medially and also serving to anchor the cartilage graft. The muscles were then pulled over about halfway on each side. These were sutured with interrupted black silk sutures. The skin and subcutaneous tissues were closed with buried silk and interrupted black silk in the skin.

The convalescence was satisfactory in that the paroxysmal attacks of cyanosis stopped and the pulse rate slowed. The healing was clean, with two exceptions. There were two small sinuses leading down to the wires, so on March 22, 1943, with the patient under nitrous oxide and ether anesthesia, the wires were removed. The wounds were filled with sulfanilamide powder. Healing was prompt, and the child was discharged on April 16, 1943, completely healed and gaining weight.

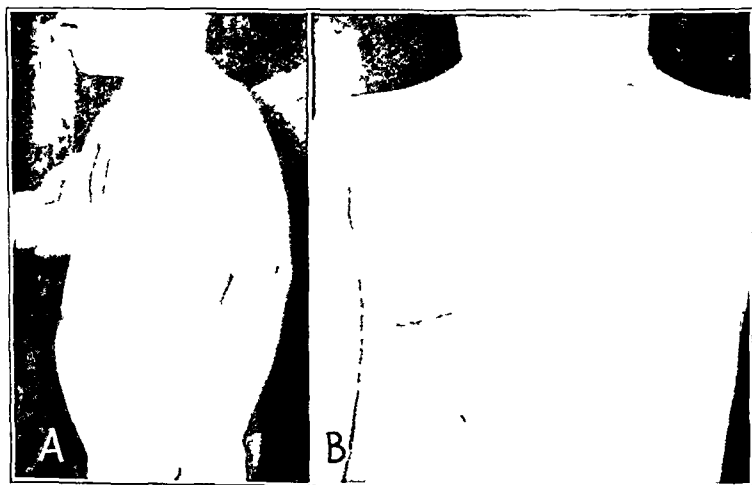


Fig 4 (case 1)—Patient aged 3 years. *A*, lateral view, showing repair. Attention is called to freedom of breathing. *B*, anterior view, showing repair.

His weight on entrance to the hospital was 9 pounds, $7\frac{1}{4}$ ounces (4,280 Gm). His weight when discharged from the hospital was 12 pounds, $3\frac{1}{2}$ ounces (5,532 Gm).

Follow-up Observation—On April 25, 1943, the child was gaining weight and progressing satisfactorily. On Dec. 10, 1943, growth was normal and the child's condition was good. On Jan. 14, 1946, at the age of 3 years, the patient weighed 10 pounds (4.5 kg); he was well developed and had no symptoms referable to the chest.

CASE 2—This case had been referred to me seven years before by Dr. William F. Hall. My record of May 8, 1937, shows that the patient had a defect of the anterior part of the sternum and manubrium which measured 2 inches (5 cm) in diameter. This defect was covered with a thin parchment-like skin, through which could be seen the pulsating heart. Surrounding the defect the bony structures were rather firm.

I was at a loss as to what to do for her but evolved the plan of having the mother make a snug 5 inch (12.7 cm) thoracic binder with a 3 inch (7.6 cm) pocket on the inside, in the portion of the binder that would cover the defect. Into this pocket was placed a piece of sponge rubber. When the binder was adjusted and made tight, the sponge rubber acted as a truss and held the heart within the thoracic cavity.

I saw the child several times during the next two years, and, although she was nervous, she was growing and the mother had made her new binders to fit as she grew. I then lost contact with her, but after the success in this later case I started a search for her.

When found, she had reached the age of 12 years and was thin and small for her age. She had continued to wear the type of support that we had fitted her with at the age of 5 years. Her condition was discussed with her parents and they agreed to have an attempt made at correction.

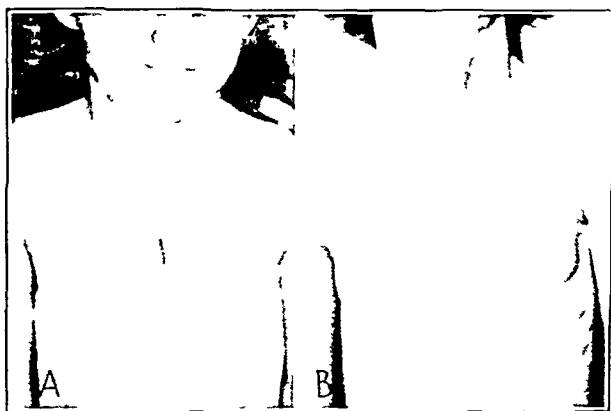


Fig 5 (case 2)—*A*, patient aged 12 years. Anterior-posterior view, showing defect of the sternum. *B*, patient aged 13 years. Note the striking improvement in development and smooth repair of the thoracic wall.

On Sept 21, 1944, she entered the Crippled Children's Hospital, and the following report is a history of her case.

B. J. H., aged 12 years, was an extremely nervous, pale, thin girl. Her eyes were prominent. Over the chin and neck were many telangiectases from irradiation of an old hemangioma.

Her neck was long and slender. The chest was symmetric. Anteriorly there was a defect of the upper two thirds of the sternum which permitted the heart to make partial excursions out of the chest with each diastole. The heart rate was 84. The blood pressure was 90 systolic and 50 diastolic. There was some clubbing of the fingers. Nothing else abnormal was found in the physical examination.

The child was put to bed and given small doses of phenobarbital with frequent high-calorie feedings.

On Sept 25, 1944, she was taken to surgery, and the following report gives the details of the procedure.

Observations—There was a defect of the anterior part and upper two thirds of the sternum which permitted the heart to make excursions partially out of the chest with each diastole. The skin was thinned out and parchment-like over the area of this defect. The heart was clearly visible through the skin. When the skin was freed, it was found that the pericardium was only partially formed and that there was no pericardium over the anterior aspect of the heart.

Operation—White soap, water and alcohol were used to prepare the anterior part of the chest. A 5 inch (12 cm) transverse incision was made over the seventh, eighth and ninth right costal cartilages, and a portion of all these cartilages was removed, so that a block of cartilage measuring 3 inches (7.6 cm) in diameter was removed. The wound was closed in layers by interrupted black silk.

A midline vertical incision was made from the level of the sternoclavicular articulation down to the level of what would normally be the level of the xiphoid process. This measured 7 inches (17.7 cm) in length. By sharp dissection, the pericardial sac was freed from its border attachments to skin. The fascia and muscular fibers were mobilized and brought together by interrupted silk sutures to close the defect in the pericardium. The entire wound was then dusted with sulianilamide crystals. The cartilage graft was laid in place and anchored with wire sutures. The skin was closed with interrupted black silk. The patient's condition was good.

On Oct. 13, 1944 she was discharged from the hospital. At a follow-up examination on March 15, 1945, the wound was solidly healed. The child was leading a more active life, and the mother stated that she was decidedly less nervous.

On Sept. 23, 1945 she was in excellent condition. She had gained 5 pounds during the summer and was more active.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

I DISEASES OF GROWING AND ADULT BONE

Prepared by

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Growth of Bone—Hendryson¹ has written a stimulating article in evaluation of the method of estimating growth of long bones published by Digby in 1916. He attempts also to arrive at a standard mean of growth in a large series of cases. His report is based on measurements of fifty-four human femurs. Needles were passed into the nutrient foramina. Mensuration from the point where they crossed the center of the medullary cavity to the obliterated epiphysal line revealed an astonishing degree of variation. Instead of growth of the distal segment of 69 per cent, as found by Digby and generally thought to be constant, the distal femoral segment was found to vary decidedly, the greatest growth being 79 per cent and the smallest 50 per cent. The percentage growth mean for the series, however, was 71 per cent, which is surprisingly close to Digby's estimate. In projecting needles into the six femurs of the series with dual arterial supply, Hendryson states that the "expected intersection of the prolonged nutrient canals did not occur in 4 instances." It should be pointed out that Digby stated that they converge on "almost" the same point in the medullary cavity. The author concludes that Digby's method of determining percentage of growth from a given epiphysal line in a long bone is unreliable and without foundation and that the figures derived from the method are inaccurate. One cannot help feeling that the average percentages of Hendryson tend to confirm Digby's estimate and strengthen the clinical impression that the increment of growth at the distal femoral epiphysal plate is about 70 per cent. Hendryson has carried out Digby's suggestion that "a thorough examination of a large series of each bone is desirable to provide reliable averages." It is realized that epiphysiodesis in the equalization of leg length is not mathematically accurate, but it is generally considered an excellent procedure and the results in reported series of cases have been favorable. Hendryson's article will not change the method of determining expected growth of an extremity,

1 Hendryson, I. E. An Evaluation of the Estimated Percentage of Growth from the Distal Epiphysal Line, *J. Bone & Joint Surg.* 27: 203-210 (April) 1945

but it is sure to precipitate reinvestigation of the question of epiphyseal growth

Kennedy² has studied the clinical histories of a series of children to determine in what conditions precocious skeletal development occurs and the factors which may be responsible for skeletal precocity. The histories of 23 patients are reviewed, and, on study, show that precocious skeletal development is not a peculiarity of any one syndrome. It may be found with or without obvious endocrine disorders and may follow the administration of endocrine preparations. Considerable material exists on retarded skeletal development. This article is an addition to knowledge of skeletal precocity.

Woolley and McCammon³ have constructed a curve of radial growth during the first two years from measurements of 400 normal infants. They postulate that the development of osseous structure is dependent on thyroxin and that deficiency is manifested not only by failure of the center of ossification to develop but by striking decrease in linear growth and by the appearance of a roentgenologically visible linear density at the epiphyseal cartilage. This dense line, they say, does not resemble that of rickets, scurvy, syphilis or lead poisoning. Adequate treatment in congenital cretins causes new bone of normal appearance to develop distal to the dense bone in three to four weeks, and as treatment continues growth parallels the normal curve. It is emphasized that the standard is applicable chiefly to congenital myxedema and only until 2 years of age. For some time the chronologic appearance of centers of ossification has been the most useful index of thyroid function during infancy. This is an interesting variation, and, since changes occur rapidly, it should be useful as a guide in the control of therapy in young cretins. The authors state that the administration of a therapeutic test with thyroid substance should be reflected visibly in the long bones within three to four weeks if true lack is present. If not, no changes will be observed.

Variation in growth within the epiphysis of the lower end of the femur is imputed as a possible cause of osteochondritis dissecans by Ribbing⁴. He postulates the presence during childhood of a superficial accessory nucleus of bone. He is of the opinion that the loose body develops from one of these nuclei which may be imagined to remain throughout childhood relatively isolated from the surrounding bone tissue by islands and bands of persistent epiphyseal cartilage, the vascular supply

² Kennedy, R. L. I. Precocious Skeletal Development. *J. A. M. A.* **127**: 589-591 (March 10) 1945.

³ Woolley, P. V. Jr. and McCammon, R. W. Bone Growth in Congenital Myxedema. *J. Pediat.* **27**: 229-235 (Sept.) 1945.

⁴ Ribbing, S. Zur Ätiologie der Osteochondrosis dissecans. *Acta radiol.* **25**: 72-75, 1944.

of which is only incompletely connected with the neighboring vessels by collateral circulation. He states the belief that a bony nucleus which is only partially connected with its surroundings might well become detached by minor traumas even though the articular cartilage remained intact.

Plasticity of Bone—Brailsford,⁵ in a thought-provoking paper presented as a Hunterian lecture, describes molding of bones into deformity due to plasticity in paralysis, scoliosis, fragilitas ossium, rickets, Paget's disease, polycystic fibrous dysplasia, Perthes' disease and many other conditions. Quotations from Hunter clearly show that he realized that bones were plastic, even without roentgenologic studies. It is brought out that gravitational and muscular forces cause deformity, which is consequently seen much more frequently in the lower extremities.

Osteochondritis—Two papers by Cole⁶ and Doub⁷ sum up present knowledge and conceptions of the various epiphyseal lesions in their clinical and radiologic aspects. They do not include, however, the condition described as *vertebra plana* (Calve).

Massaro⁸ reports a case of *vertebra plana* with an eleven year follow-up and carefully differentiates it from Scheuerman's disease. The change is one of primary aseptic necrosis, usually of a single vertebra. The author prefers the designation *vertebra plana* to other names by which the condition is sometimes known. The destructive phase lasts about two months, and the regenerative phase is greatly protracted and may extend through a period of eight years or more. While *vertebra plana* may be descriptive of the late stage, it is probable that it is inappropriate for the earlier stages, just as *coxa plana* is descriptive of only a late stage of Perthes' disease.

Osteitis Deformans—A paper by Dickson, Camp and Ghormley⁹ constitutes a carefully worked out report on 367 patients with osteitis deformans. The authors have studied the roentgenograms of 200 of these patients. After noting the variations of architecture, they classify the disease into two phases, the sclerotic and the combined. The sclerotic phase is characterized roentgenographically by a homogeneous increase in density of bone, with detail of the cancellous trabeculae no longer perceptible. The combined phase represents nonhomogeneous alterations of density of bone represented roentgenographically by areas of osteo-

5 Brailsford, J. F. Plasticity of Bone, *Brit. J. Surg.* **32** 345-357 (Jan.) 1945.

6 Cole, W. H. The Clinical Diagnosis, Treatment and Prognosis of Epiphyseal Disturbances in Childhood, *J. A. M. A.* **127** 318-320 (Feb. 10) 1945.

7 Doub, H. P. Aseptic Necrosis of the Epiphyses and Short Bones, *J. A. M. A.* **127** 311-317 (Feb. 10) 1945.

8 Massaro, A. F. *Vertebra Plana* (Calve), *Radiology* **45** 284-291 (Sept.) 1945.

9 Dickson, D. D., Camp, J. D., and Ghormley, R. K. Osteitis Deformans, Paget's Disease of the Bone, *Radiology* **44** 449-470 (May) 1945.

porosis, osteosclerosis and cysts. The paper accentuates other known facts about the disease. Familial incidence was observed. Twenty per cent of the patients had no complaints, the presence of the disease being discovered incidentally in the course of roentgenographic investigation. The most striking alteration observed in the blood of patients having osteitis deformans was elevation of the serum phosphatase level. Seventy-seven pathologic fractures occurred in the series, and sarcoma occurred in 3 instances. The authors state the belief, on a basis of their extensive study, that osteoporosis circumscripta is an early roentgenographic manifestation or precursor of osteitis deformans of the skull. Whereas earlier authors believed the skull and tibia to be the most frequent sites of the disease, this series reports the high incidence of 243 patients in 387 showing involvement of the pelvis.

Jacobs¹⁰ describes a case of osteoporosis circumscripta crani and expresses the opinion that it constitutes the early stage of Paget's disease. He feels that the condition should be looked for and a diagnosis made early in many instances on dental examination.

Seligman and Nathanson¹¹ report a case of Paget's disease with gross calcification of the soft tissues of the lower extremities. The patient received calcium and viosterol, but the authors express the belief that this was concomitant and not causal.

Hyperparathyroidism—As a result of a deliberate attempt to improve diagnostic accuracy, Keating and Cook¹² state that 24 cases of hyperparathyroidism were discovered in two and one-half years at the Mayo Clinic, whereas only 14 cases were observed during the previous fourteen years. They emphasize that discovery of an increasing number of cases is entirely a reflection of a high index of suspicion and revision of the criteria necessary to make a diagnosis. Classic osteitis fibrosa cystica existed in only 7 of the 24 cases reported. In 9 there was mild or atypical disease of the bone, and in 8 no disease of the bone existed. They emphasize the frequency of calcification of the kidney or renal calculi, having found it in 92 per cent of their cases. An even more striking fact is that the chief clue to the diagnosis in 75 per cent of the cases was the presence of renal calculi. Prolonged study of the blood chemistry is often necessary to establish the diagnosis, which depends on the demonstration of an increase of calcium and a reduction of inorganic phosphorus in the serum as well as a reduction of

10 Jacobs M H. The Jaws in Paget's Disease (Osteitis Deformans) with Special Reference to Osteoporosis Circumscripta Crani, *Am J Orthodontics* (Oral Surg Sect) **31** 104-110 (Feb) 1945.

11 Seligman B and Nathanson L. "Metastatic" Calcification in Soft Tissues of Legs in Osteitis Deformans. *Case Ann Int Med* **23** 82-91 (July) 1945.

12 Keating F R Jr and Cook E N. The Recognition of Primary Hyperparathyroidism. *J A M A* **129** 994-1002 (Dec 8) 1945.

calcium in the urine. The authors concluded by reemphasizing the conclusion of Albright and his colleagues that (1) hyperparathyroidism is commoner than generally supposed, (2) renal involvement is more frequent and diagnostically more important than osseous involvement and (3) every patient who has renal calculi should be suspected of having hyperparathyroidism until the contrary is clearly proved or until some other etiologic factor can be clearly demonstrated.

McClure and Lam¹³ report 6 cases of hyperparathyroidism. Four patients were successfully treated by removal of adenomas. One died of acute parathyroid intoxication without the benefit of surgical intervention which had been advised. The other death occurred after operation on a patient in a hypoparathyroid state. As a result of their experience with these cases, the authors advise more frequent determinations of blood calcium levels in persons with symptoms of pressure on the nerve root, muscle pain and renal calcification and stones in order that a diagnosis can be made prior to the stage of *osteitis fibrosa cystica* or before spontaneous fractures have developed.

Fibrous Dysplasia of Bone—There is currently a great deal of interest shown in fibrous dysplasia of bone, and numerous articles have appeared which add valuable information to the sum total of knowledge on the subject. Scholder¹⁴ reports the case of a female patient followed over a period of eleven years, with relatively slight change in that period, presenting the diagnostic triad: precocious puberty, fibrocystic bone changes and cutaneous pigmentation. He advances a new hypothesis that the syndrome results from a hypothalamic (pituitary) parathyroid disturbance.

Coley and Stewart¹⁵ record the only 2 instances in the literature of malignant tumor of the bone occurring in fibrous dysplasia, thereby adding this condition to the group of diseases of the bone in which in certain instances malignant tumors of bone develop.

By far the most illuminating article on the subject is that of Jaffe.¹⁶ He reemphasizes his earlier work, centering the disorder as a whole about the skeletal involvement, and his belief that the instances classified as Albright's disease are simply the most florid examples of the disorder as a whole. The author takes particular exception to the work of

13 McClure R. D., and Lam, C. R. End-Results in the Treatment of Hyperparathyroidism, *Ann Surg* **121** 454-469 (April) 1945

14 Scholder, B. M. The Syndrome of Precocious Puberty, Fibrocystic Bone Disease and Pigmentation of the Skin. Eleven Years' Observation of a Case. *Ann Int Med* **22** 105-118 (Jan) 1945

15 Coley, B. L., and Stewart F. W. Bone Sarcoma in Polyostotic Fibrous Dysplasia, *Ann Surg* **121** 872-881 (June) 1945

16 Jaffe, H. L. Fibrous Dysplasia of Bone, *J Mt. Sinai Hosp* **12** 364-381 (May-June) 1945

Thannhauser in 1944, which attempted to establish the thesis that fibrous dysplasia of bone is not an independent entity but that it is related by its clinical and histologic features to neurofibromatosis of Recklinghausen. Jaffe separates the entities and differentiates them clearly and convincingly. The article, to be properly appreciated, should be read in full.

Gaucher's Disease—Tennent¹⁷ describes what he refers to as a diagnostic osseous sign of this rarest of the three lipid storage diseases. The disease has been recorded in two forms, which may be referred to as visceral and osseous. The diagnostic points roentgenologically are found by study of the roentgenograms of the femurs. Well marked osteoporosis, which increases in degree from above downward, is an important sign. Expansion of the distal end of the femur is seen. There is found also a true over-all increase in breadth, but the diagnostic feature is a loss of the normal concavity above the medial femoral condyle. This is progressive, becoming a straight line and later a convexity. Cortical thinning and small medullary areas of erosion of trabeculae constitute the third sign.

Rickets—Dunham and Thoms¹⁸ report on a study of 10 children who had severe rickets in childhood and who were reexamined in adolescence. Five had rachitic pelvis in adolescence, and 5 had nonrachitic pelvis. As a result of their findings, they express the opinion that the older the child is when rickets is present, the greater the chance that pelvic deformity will occur. The entire group had, in adolescence, some deformity of the lower extremities. High ratios of sitting height to standing height were found in all but 1, which suggests retardation of growth of the lower extremities.

Scurvy—Evans¹⁹ reports a series of 93 cases. Sex distribution is about equal, and there was a striking limitation of cases to the latter part of the first year. Stages of the disease as it appears roentgenologically in order of their appearance are described and include ground glass type of demineralization, signet ring appearance of the epiphyses, submetaphyseal notching, fragmentation or separation of the metaphysis and displacement of the epiphysis. Two important types of periosteal shadow are described, one appearing as a narrow triangular shadow, having its base at the metaphysis and extending up the shaft, and the other larger, more club shaped and extending along the greater length of the shaft. The differential diagnosis is discussed, including rickets, infection, trauma and neoplasm.

17. Tennent W. Gaucher's Disease—The Early Radiological Diagnosis. *Brit J Radiol* 18: 356-358 (Nov.) 1945.

18. Dunham E. C. and Thoms H. Effects of Severe Rickets in Early Childhood on Skeletal Development in Adolescence. *Am J Dis Child* 69: 339-345 (Jan.) 1945.

19. Evans W. A. Jr. Periosteal Lesions in Scurvy. *Am J Roentgenol* 53: 147-156 (Feb.) 1945.

Phosphatase—Silver and Golding²⁰ conducted experiments in vitro and in vivo to explain delay in healing of compound fractures with particular reference to sulfonamide therapy in the wound. They found in maximal concentrations obtainable clinically in the blood that sulfanilamide, sulfapyridine and sulfathiazole produce no inhibition of bone phosphatase in vivo or in section. In maximal concentrations obtainable in tissues as a result of local application sulfanilamide produces over 50 per cent inhibition of activity of bone phosphatase. Sulfapyridine and sulfathiazole on the other hand produce only slight inhibition. As a result of their experiments they suggest that sulfanilamide should not be used clinically as a local application in sites of fracture.

Calcification—Vitamins to some extent at least the "bread pills" of this generation, are generally looked on as being relatively harmless. Striking evidence of the potency of vitamin D in massive doses over a protracted period, however, is presented by Danowski, Winkler and Peters.²¹ The authors present 2 cases which show that it is possible to produce calcification in soft tissues and renal failure. They express the opinion that the sequence of events is hypercalcemia, which increases the calcium content of the soft tissues, notably the kidneys, followed by renal calcification, which is the cause of renal failure. Fortunately the process is reversible to some extent by discontinuance of the therapy.

Freyberg and Bauer²² report a fatal case of vitamin D intoxication with metastatic calcification.

II CONGENITAL DEFORMITIES

Prepared by

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Experimental—For the past four years this review of congenital deformities has recorded additional contributions to this puzzling subject by Josef Warkany.²³ He points out that congenital malformations represent an important pediatric problem also, since they are a notable factor in infant mortality and in children's morbidity. Genetic, infectious

From the Scottish Rite Hospital For Crippled Children

20 Silver, P. H., and Golding, J. S. R. Effects of Sulfonamides on Bone Phosphatase. *Lancet* **1**: 528-529 (April 28) 1945.

21 Danowski, T. S., Winkler, A. W., and Peters, J. P. Tissue Calcification and Renal Failure Produced by Massive Dose Vitamin D Therapy of Arthritis. *Ann. Int. Med.* **23**: 22-29 (July) 1945.

22 Freyberg, R. H., and Bauer, J. M. Vitamin D Intoxication with Metastatic Calcification. *Univ. Hosp. Bull., Ann Arbor* **11**: 61 (Aug.) 1945.

23 Warkany, J. Congenital Malformations Induced by Maternal Nutritional Deficiency. *J. Pediat.* **25**: 476-480 (Dec.) 1944.

and actinic factors have been proved to be etiologic principles leading to malformations. He has also shown that malnutrition of the embryo can be an etiologic factor.

It has been observed that animals fed poor diets gave birth to blind young. Warkany raised female rats on a highly purified diet free of carotene and vitamin A. The few rats able to terminate pregnancy produced young which were born blind and had deformed eyes. This is due to an arrest of development in an early embryonic stage. If vitamin A is added to the maternal diet, these deformities are not observed.

In previous articles on "Progress in Orthopedic Surgery" deformities have been listed which followed diet I. These were prevented by adding 2 per cent dried liver. The vitamin B complex was preventive. When the crystalline substances of vitamin B were tried, it was found that thiamine hydrochloride, nicotinic acid, pyridoxine and pantothenic acid, either alone or in combination, were ineffective. Riboflavin was found to be as preventive as liver. It was found that the aforementioned malformations could be prevented by administration of liver as late as the thirteenth day of gestation. He interprets this as proof that these malformations are not determined before the thirteenth day of prenatal life.

He says

Histologic sections show that the malformations are present already in cartilaginous structures which indicates that the deviation from the normal development occurs before or at the stage of chondrification. Chondrification begins in the rat on the fourteenth and fifteenth days of fetal life. Thus, we can conclude that the malformations are determined not before the thirteenth day and not after the fifteenth day of gestation. A critical stage exists then in the 13- or 14-day rat embryo in which the presence or absence of sufficient riboflavin is of a decisive influence on the development of the embryo. At about this time most of the affected parts of the skeleton undergo rapid changes. Undifferentiated mesenchymal structures develop into the well-differentiated membranous skeletal elements which are the forerunners of the cartilaginous and osseous skeleton. This change from mesenchyme into the membranous skeleton seems to be impaired by a deficiency in riboflavin. The membranous skeleton exists only during a short period in prenatal life and therefore not much attention is paid to its morphology and physiology. But its constitution determines the fate of the permanent skeleton and its vulnerability deserves our special attention. It is of great interest to learn that riboflavin, a vitamin known to be necessary for normal growth, is also necessary for normal embryonic differentiation.

When he left the vitamin D out of diet I, he had a rachitogenic diet and the deformities were of a different pattern. The ulna, radius tibia and fibula were decidedly curved, and the ribs showed a peculiar angulation and broadening within their osseous parts. This pattern of malformation could be prevented when the maternal diet was supplemented by vitamin D.

Grebe²⁴ cites some statistics to demonstrate the incidence of congenital deformity. Thus Strohofer in 1933 reported an incidence of 0.5 per cent, Unterrichter in 1935 reported 1.3 per cent and Herrmann in 1939 reported 2.4 per cent of their admissions. Evidently congenital deformity is not rare. About one tenth of stillborn children are deformed and about one fifth of those dying within the first six months of life. After a discussion of the probability of further deformed offspring following the birth of infants with chondroplasia, syndactylism and polydactylism, cleft palate and harelip, cranioschisis, including anencephaly and spina bifida, malformations of the heart, and mongolism, the author concludes that none of these conditions justify sterilization, since the exact probability of recurrence has not been estimated. However, he suggests that the danger of producing abnormal offspring is greater when milder anomalies have already appeared in siblings. Some deformities are so slight that they would not affect the health. Severe deformities leading to prenatal death are less likely to be repeated in later offspring. In giving advice to prospective mothers one must consider not only the occurrence of deformity in siblings but also the condition of the general anlage, thus avoiding exclusion of good material because of slight defect.

Gregg²⁵ in 1941 found an unusual type of cataract in infants in Sydney, Australia. There was a remarkable similarity of the opacities of the lens, and a congenital defect of the heart frequently accompanied it. He found that all the mothers had had an attack of rubella during the first or second month of pregnancy. The health of the mother during the remainder of pregnancy was good. With the help of his colleagues 78 cases were collected. Some of these infants presented deaf-mutism. He refers to the work of Miss Mann, who showed that there was a relationship between a virus infection early in pregnancy and the appearance of certain congenital defects in the infant. She said that the most important determining factor in human beings for the effect of a maternally transmitted disease was the time of its action, only the cells which were in active division being affected. She showed that the time of the active division of the cells of the lens, internal ear and heart was at the time of the illness. The question is asked whether other diseases might not have a harmful effect on the developing embryo.

Greenthal²⁶ reports 2 additional cases from Milwaukee and gives references to others who have verified the fact that rubella during the

24 Grebe, H. Angeborene Missbildung und weitere Kinder. *Med. Klin.* **39** 484 (July 9) 1943.

25 Gregg, N. M. Rubella During Pregnancy of the Mother with Its Sequelae of Congenital Defects in the Child, *M. J. Australia* **1** 313-315 (March 31) 1945.

26 Greenthal, R. M. Congenital Malformations in Infant Caused by Rubella Early in Pregnancy. Report of Two Cases. *Arch. Pediat.* **62** 53-56 (Feb.) 1945.

first two months of pregnancy will cause deformities in infants. He wonders why similar cases have not been seen before and whether rubella has been severer during the last few years. He says:

I believe that if rubella is the cause of such serious congenital malformations in the infant then there should be no effort made to isolate children from rubella. I also agree with the suggestion that if a woman contracts rubella during the first two months of pregnancy a therapeutic abortion is justified, as the chances of congenital defects affecting the infant are about one hundred per cent.

Adams reports 2 new cases of patients showing both congenital cataracts and congenital defects of the heart. The importance of preventing rubella and other infections during the early months of pregnancy is pointed out.

Albough²⁶ has added 9 cases of congenital anomalies following maternal rubella in early pregnancy. He reviews the literature and analyzes the 78 cases reported. The commonest congenital lesions in the infants are cataracts, cardiac septal defects and patent ductus arteriosus, deaf-mutism and microcephaly. There was only 1 case of clubfoot reported. Nearly all the infants are poorly developed and present problems in feeding. The available data suggest that 100 per cent of the mothers who contract rubella in the first two months and approximately 50 per cent of those who contract it during the third month will give birth to infants with congenital anomalies.

In 1940 to 1942 congenital malformations were reported on 3,180 and birth injuries on 2,246 of the birth certificates filed in the state of New York, outside of New York city.²⁹ That in many cases malformations or injury were not recognized at birth or not reported by the attending physician is demonstrated by a comparison of the causes of death of children under 1 month with the statements on the corresponding birth certificates and likewise by a comparison with the Crippled Children's Register. On this basis a minimum estimate of malformations would be twice and birth injuries four times the reported figures.

Congenital malformation multiplies by at least 13 the risk of a child's dying in the first month of life and by 9 at 1 to 11 months. Birth injury raises the risk of death elevenfold during the first month but has no effect on the mortality of children aged 1 to 11 months.

²⁷ Adams, F. H. Rubella in Pregnancy and Congenital Malformations, *Journal Lancet* 65:197-198 (May) 1945.

²⁸ Albough, C. H. Congenital Anomalies Following Maternal Rubella in Early Weeks of Pregnancy with Special Emphasis on Congenital Cataract. *I. A. M. A.* 129:719-723 (Nov. 10) 1945.

²⁹ DePrete, I. A. and Parkhurst, E. Congenital Malformations and Birth Injuries Among the Children Born in New York State, Outside of New York City 1940-1942. *New York State J. Med.* 45:1097-1100 (May 15) 1945.

A case of blue sclerotics associated with a giant cell tumor in one eye of a Chinese schoolgirl was seen and reported by Chan³⁰ Biomicroscopic studies as well as anatomicopathologic examinations of the enucleated eye showed thinning of the cornea, which was about three fourths as thick as that of a normal eye. Anatomic section demonstrated that the sclera was from one third to two thirds as thick as that of a normal eye, the ratio varying in different regions. Biochemical analysis of the sclera disclosed the presence of an abnormally large quantity of calcium. The author concludes, "It is believed that hyperfunction of the parathyroid glands may be a factor in the causation of this anomaly."

[ED NOTE (J H K)]—Blue sclera and brittle bones may be a rare condition in an eye clinic but such cases are continually being seen in orthopedic clinics. They run in families and often through several generations. There is no evidence in this 1 case or in the reported cases that it is the result of a hyperparathyroid condition.]

A case of generalized neurofibromatosis accompanied with congenital deformities of the first three cervical vertebrae is reported by Peacock.³¹ An operation was done to remove a tumor mass under the jaw. The patient died suddenly three days later, and autopsy findings, including the fusion of the first three cervical vertebrae, are given in detail. He says

The osseous conditions associated with generalized neurofibromatosis fall into two main groups. In one congenital skeletal defects occur. Kypho-scoliosis is frequently present, spina bifida and defects of the bony wall of the orbit are described. In the other, there are osseous manifestations directly due to the disease, exemplified by the results of periosteal lesions resulting in overgrowth of bony tissue and the enlargement of bones seen in various situations.

[ED NOTE (J H K)]—Many of the so-called congenital hypertrophies of parts or of the entire extremity are due to changes in the nerves to the part. There is an enlargement of the bone as well as of the soft parts. On careful examination patients with these conditions will show café au lait spots and when older neurofibromas.]

Brown and Pearce³² wrote three papers on hereditary achondroplasia in the rabbit. The first has to do with the physical appearance. They summarize by saying that it is present at birth and is characterized by

30 Chan, E. Blue Sclerotics Associated with Bony Defects. I. Internat. Coll. Surgeons 8:140-144 (March-April) 1945.

31 Peacock, A. Developmental Abnormalities of Cervical Vertebrae in Case of Generalized Neurofibromatosis, Post-Grad. M. J. 20:324-328 (Nov.) 1944.

32 Brown, W. H. and Pearce, L. Hereditary Achondroplasia in Rabbit. Physical Appearance and General Features. J. Exper. Med. 82:241-260 (Oct.) 1945. Pearce, L. and Brown, W. H. Hereditary Achondroplasia in Rabbit. Pathologic Aspects, *ibid.* 82:261-280 (Oct.) 1945. Hereditary Achondroplasia in Rabbit. Genetic Aspects. General Considerations *ibid.* 82:281-295 (Oct.) 1945.

reduction in size, by a disproportion of bodily parts, most striking in the extremities, and by an invariably lethal effect. The animals are stillborn or die shortly after birth.

In physical appearance and in the character of the skeletal changes as shown by roentgenograms, achondroplasia in rabbits has a remarkable resemblance to the disease in human beings and in cattle and dogs. The condition which first occurred in offspring of purebred Havana rabbits is inherited. The mode of inheritance is on the basis of a simple recessive unit factor and the appearance of nonachondroplastic transmitters (heterozygotes) is that of normal animals.

In the second paper they discuss the pathologic aspects.

At autopsy the chief features of interest are reduced size with proportionately shortened extremities and large head, cutaneous and subcutaneous edema of variable degree and distribution, small shortened bones with a cartilaginous appearance and texture, immature teeth, and cleft palate in one-fourth the cases, blood-stained fluid in the thoracic and abdominal cavities, a comparatively small heart pointing to the right of the midline, a very large firm thymus, a large pale soft spleen, a large swollen liver with red mottling, and a stomach distended with thin greenish mucus but no milk.

The mean relative weights of all organs in terms of the net body weight were larger than those of normal new-born litter mates. The mean actual weights of the kidneys, the brain and especially the spleen and the thymus were also larger than their respective normal values, those of the heart, liver, and adrenals were slightly smaller, while that of the pituitary was the same.

Histologically all endochondral cartilages show marked abnormalities of differentiation with pronounced deficiency of ossification. Calcification of membranous bones is likewise deficient. The histological abnormalities of the long bones are very similar to, if not identical with, those characteristic of human fetal chondrodystrophy, the creeper fowl condition, the "bull-dog" calf, and achondroplasia of the dog.

No histological evidence was found in any organ which would suggest a basis for a responsible causal agent of the abnormality.

The third paper has to do with the genetic aspects and general considerations. It is the first instance of this abnormality in rodents to be reported. The variation arose in purebred Havana stock.

The abnormality is determined by the expression of a simple recessive unit factor, affected persons being homozygous for the factor. Females are somewhat more frequently affected than males, but the character is not sex linked. Rabbits heterozygous for the factor as determined by appropriate breeding tests have a perfectly normal appearance at birth and in later life.

The condition appears to be determined solely by the genetic constitution of the animal. Attention was drawn to the fact that, although the development of the achondroplastic form proceeds to birth at term, death regularly occurs at the time of or shortly after parturition.

Congenital absence of the odontoid process from the cervical axis has been reported in 1 case by Roberts and in 2 cases by Weiler Scannell - adds another, that of a soldier who suffered sharp pain in the neck after a twist sustained while wrestling. The pain was accompanied with generalized weakness most noticeable in the arms. During the half-hour following injury, the weakness gradually disappeared. Roentgenographic studies, including laminagrams, revealed a complete absence of the odontoid process and abnormal mobility of the atlas on the axis in flexion and extension.

Allen³⁴ gives a good review of the literature and reports the findings in a Negro soldier who had engaged in strenuous infantry training for seven months without symptoms. He lists nineteen malformations in the upper part of the spine and thorax.

Ingersoll³⁵ presents a case of bilateral congenital high scapula with bilateral omovertebral bones which was treated by surgical removal of these structures, yielding functional improvement and giving some cosmetic benefit.

Grieve³⁶ reports 7 cases of congenital subluxation of acromioclavicular joint in the course of medical examinations in the air crew. In every instance the condition was bilateral. These cases show that mere displacement of the clavicle above the acromion need produce no disability.

A case of congenital recurrent dislocation of the head of the radius is reported by Bindman³⁷ because of its rarity and because it was recurrent and reducible. The case was that of a girl of 9 who had a dislocation of the head of the right radius while attempting to loosen a button on the left shoulder with her right hand. She felt a sudden pain in the right elbow and noticed a lump in front of the elbow, which disappeared on manipulation. The pain was momentary and not severe. Roentgenograms showed that the head of the radius was shallow and poorly formed.

Up to the present time some 24 cases of congenital humeroradial synostosis have been reported, nearly all of them in European literature. It is apparent that there is a hereditary tendency since some have

33 Scannell, R. C. Congenital Absence of Odontoid Process. Case Report. *J. Bone & Joint Surg.* **27** 714-715 (Oct.) 1945.

34 Allen, W. E., Jr. Klippel-Feil Malformation. Report of Case in Adult. *Radiology* **44** 79-81 (Jan.) 1945.

35 Ingersoll, R. E. Congenital Elevation of Scapulae with Bilateral Omovertebral Bones. *New York State J. Med.* **45** 1462-1463 (Jul. 1) 1945.

36 Grieve, I. Congenital Subluxation of Acromioclavicular Joint. *Lancet* **2** 817-818 (Dec. 23) 1944.

37 Bindman, E. Congenital Recurrent Dislocation of Head of Radius. *Brit. M. J.* **2** 354 (Sept. 15) 1945.

reported 2, 3 and even 4 such cases in the same family. Murphy and Hanson³⁸ report an infant born of normal parents who could not move his elbows, and the roentgenograms showed that there was no articulation at all at the elbow, the radius and humerus were one continuous bone.

Prof. Munir Ahmed Sarpyener, of Istanbul, Turkey, shows that many of the conditions which have been attributed to spina bifida are in fact due to congenital stricture of the spinal canal.³⁹ He says that it is a common phase of pathologic change that peripheral nerves are susceptible to pressure, whether this be the sudden pressure of a fractured bone fragment, the gradual pressure of exuberant callus or the slow envelopment of scar tissue.

Thus far there have been no references in the medical literature to congenital stricture not associated with spina bifida occulta. Studies extending over a long period have convinced me, however, that this pathological entity does exist, that it can be demonstrated by suboccipital injections of lipiodol, and that it is responsible for many hitherto unexplained clinical manifestations—enuresis, spastic or flaccid paralysis, and various deformities.

Just as tumors of the spine may cause spastic or flaccid paralysis, so congenital strictures may produce one or the other form of paralysis. The particular type is due not to the location of the lesion, but to the degree of pressure exerted on the cord.

Thus far, I have been able to differentiate the following forms of congenital stricture of the spinal canal:

1. A narrowing of the canal, forming a ringlike constriction of the cord at one or more levels. This variety is usually found in cases of enuresis, and is readily cured by laminectomy. The relief of symptoms comes within a few hours of the operation.

2. More extensive strictures, involving an entire region of the canal. This type is usually associated with spastic paralysis similar to that seen in Little's disease.

3. A localized stricture causing compression of the spine and paralysis of certain groups of muscles. This is the type responsible for club-foot.

4. Atypical cases causing a cleft either in the cord alone or in both cord and dura mater.

He presents many photographs and roentgenograms to show the remarkable improvement following laminectomy to relieve the pressure on the cord.

That the spinal canal may be greatly dilated as the result of an intraspinal neoplasm is well known, but that an equally pronounced dilatation may occur at any level as the result of a congenital anomaly of the cord structures is not generally recognized. Walker⁴⁰ reports

³⁸ Murphy, H. S. and Hanson, C. G. Congenital Humeroradial Synostosis. *J. Bone & Joint Surg.* **27**: 712-713 (Oct.) 1945.

³⁹ Sarpyener, M. A. Congenital Stricture of Spinal Canal. *J. Bone & Joint Surg.* **27**: 70-79 (Jan.) 1945.

⁴⁰ Walker, A. I. Dilatation of Vertebral Canal Associated with Congenital Anomalies of Spinal Cord. *Am. J. Roentgenol.* **52**: 571-582 (Dec.) 1944.

3 cases of myelodysplasia associated with dilatation of the spinal canal at the site of the anomaly. A case of vascular abnormality—angioma and aneurysm—of the spinal canal at the site of the lesion is also reported. The roentgenographic and pathologic manifestations of myelodysplasia are discussed. Although neoplastic conditions cause most instances of roentgenographically demonstrable enlargement of the spinal canal, congenital abnormalities of the spinal cord should be considered as etiologic factors.

A case of intrapelvic protrusion of the acetabuli is reported by Thoroughman⁴¹ which is unique in that the hip symptoms are completely absent except for pain in the right knee. Otto originally described this condition in 1824, and only about 100 cases have been reported. It has been called Otto's pelvis, protrusion acetabuli and arthrokatachysis. These names should not be applied to deformities following trauma or metastatic processes. Neither should the conditions following infections be so classified. This condition probably results from a general disease in early life which has caused a softening of the bones. When osteoarthritis is seen, this is a later stage superimposed on a preexisting deep acetabulum. The intrapelvic protrusion is frequently asymptomatic until osteoarthritis occurs. The most constant physical findings are limitation of motion, particularly in abduction and external rotation. There is a rather constant flexion deformity with a compensatory lordosis. Therapy is unsatisfactory.

Mahaffey⁴² reports the case of a soldier who had a fracture of the right lateral malleolus four years previously and who had continued to have pain in his foot. Roentgenologic examination revealed no space between the os calcis and the cuboid. A roentgenogram was made of the other foot, which had given him no trouble, and it showed the same.

[ED. NOTE (J. H. K.)—Fusion of the calcaneocuboid joint is seen as the only deformity rarely and is frequently seen when associated with other deformities of the foot. This condition occurs much more frequently than the reported cases would indicate, because there is little reason for reporting congenital fusions.]

Veneruso⁴³ reports a soldier who had pain along the inner border of his right foot after prolonged walking or standing. He had only four toes on that foot. Roentgenograms revealed the complete absence

41 Thoroughman, J. C. Intrapelvic Protrusion of Acetabuli, *Am. J. Surg.* 69:238-242 (Aug.) 1945.

42 Mahaffey, H. W. Bilateral Congenital Calcaneocuboid Synostosis. Case Report. *J. Bone & Joint Surg.* 27:164-165 (Jan.) 1945.

43 Veneruso, L. C. Unilateral Congenital Calcaneocuboid Synostosis with Complete Absence of Metatarsal and Toe, *J. Bone & Joint Surg.* 27:718-719 (Oct.) 1945.

of one metatarsal and its phalanges and a fusion of the calcaneus and cuboid bones. No evidence of a joint between these bones could be found.

Mathews⁴⁴ states that good results can be obtained in almost all cases of congenital clubfoot if treated immediately. The inner structure of the foot and mechanical aspects are discussed. By utilization of growth pressure and delicate maneuvers tolerable even in newborn infants, a cure can be accomplished in a short time. The author describes a splint and cast. Treatment can begin on the day of birth, and cure is usually finished by the fourth month. No after-treatment is needed. The developmental cause of clubfoot is discussed. This is a false position of the supporting arch which in pathologic supination carries with it the great toe without changing its shape or position in relation to the arch.

All other changes are caused by secondary lesions. Clubfoot in newborn infants is easily corrected by finger pressure, which may be applied in several sittings in cases of severe deformity, at intervals of two to three days. A plaster cast is applied after pronation, and the forces preventing a harmful effect will have a corrected effect. Once reduced by finger pressure the position is maintained by application of a splint and the foot fixed by strips of pasteboard to prevent lateral compression. The foot is placed in exaggerated abduction. Bits of rubber sponge are applied between the splint and leg and the transverse band and the external margin of the foot. Care must be exercised that traction and pressure do not counteract each other, with resulting injuries to the skin. The dressing is renewed every few days in a further corrected position. After overcorrection has been achieved a plaster cast is applied, the inner and outer margins of the foot being protected with cotton. The cast is applied to halfway up the thigh, the knee and thigh flexures being left free. Shortly before the plaster hardens, the foot is placed in the greatest possible position of overcorrection, with special attention to the heel. Shortly after hardening the cast is split. Both growth forces and movement are utilized as curative forces. A change is evident even after fourteen days. The cast should not be left on for more than three weeks or too extreme pronation might result. After two or, at most, three weeks the thigh portion of the cast should be removed, and the knee is extended for one week to stretch the calf muscles. The cast is then reapplied in improved position. The thigh portion of the cast is removed from five to six times. When the foot remains in corrected position even against finger pressure, treatment is discontinued. Dorsal flexion and abduction following irritation of the sole prove that the peroneal muscle has recovered and that there is no danger of relapse. Six cases are reported.

⁴⁴ Mathews, H. Die Sofortbehandlung des angeborenen Klumpfusses. *Ztschr. f. Orth.* 74: 272, 1943.

The "medical treatment of clubfeet is discussed in a rather theoretic article by Leonard⁴ He says

In medicine there are many occasions when there is a need for active treatment even though the mechanism which has produced the abnormal condition remains obscure

It would seem that it should be possible to determine the exact age which is most satisfactory for successful treatment of a clubfoot by nonsurgical methods and that complete restoration of a fully functioning foot should be possible at that age in every case

In other words, the failure is thought of as being the result of insufficient rather than wrong treatment

If the process of ossification in the tarsal bones holds the clue to the problems of treatment of clubfoot and if the treatment is to be thought of as, first a correction of the deformity and second a period of waiting for the elements of the foot to "set" in their proper shape like cooling plastic, the individual time schedule of ossification is of primary importance

It may also be concluded that there is a certain percentage of abnormal delay in the appearance of ossification in those cases which have presented the greatest difficulty in the prevention or relapse

An interesting corollary to the idea that delayed ossification effects the progress of recovery is a speculation regarding a possible relation between it and the etiology of clubfoot [Clubfoot] appears twice as often in boys as in girls It has also been shown that the rate of ossification as a normal average in boys is slower by several months than in girls A relative slowness of normal ossification is, therefore, found coupled with a relative greater incidence of clubfoot

He uses an "ossification index," which is the year a given epiphysis usually appears If there is a delay in the appearance of the center of ossification in the roentgenogram, the outlook is unfavorable and the foot should be held longer under treatment If the appearance is normal, the prognosis is good and the foot will retain its correction He expresses the opinion that a delay in the ossification of the tibial epiphysis may explain the inward torsion present in many of these cases In cretins the delay in ossification is stimulated by the giving of thyroid From work on rats he states the belief that the administration of thyroid should be accompanied with administration of anterior pituitary growth hormone

He concludes

Medical treatment for the purpose of speeding ossification in a child with clubfoot through the period when the bones are being held in their normal position thus becomes a matter of giving adequate daily doses of thyroid substance with extra thiamine chloride which this medication demands and with the theoretical assistance of a diet rich in calcium, phosphorus, and vitamins A and D

[ED NOTE (J H K) —All who have treated clubfeet are familiar with the fact that some feet respond easily to corrective treatment and

⁴ Leonard, D W Significance of Delayed Ossification in Treatment of Congenital Clubfoot J Pediat 26 379-389 (April) 1945

others are difficult to correct and that these same conditions have a great tendency to recur. Frequently in bilateral conditions in which the rate of development might be expected to be the same in each foot, one foot will be more difficult to correct, even though it has had exactly the same treatment throughout. It is also known that there is a wide variation in the appearance of the centers of ossification for the bones of the feet. I have seen in clubfeet a center for the scaphoid at 2 years and have seen other untreated clubfeet in which it did not appear until 7. As soon as treatment was begun it made its appearance. I have studied grossly the time of development of the center of ossification in more than 500 patients with clubfoot and have not been able to deduct any rules of procedure. It is difficult to say whether a delay in ossification is the cause of the abnormality or the result of it. If a study of the roentgenograms of the feet shows that there is a slight delay in the appearance of ossification at 2, 3 and 4 years in the respective bones in boys, it is difficult for me to see how this can be responsible for twice as many boys having clubfeet, when this deformity becomes fixed early in the development of the embryo.]

III TUMORS OF BONE AND OF SYNOVIAL MEMBRANE

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Osteitis Fibrosa Cystica—Krigsten and Phalen⁴⁶ report 3 cases of fibrocystic disease of the femur in young soldiers. Treatment by means of curettage and bone graft gave satisfactory results. Pathologic fractures were the first evidence of the lesion in 2 of the cases. The authors state the opinion that cysts of bone arise as a result of localized congenital abnormality rather than as the result of hemorrhage. They distinguish two types of cysts of bone: the first, the fluid-filled, true cystic type lined by connective tissue and, the second, the fibrous "solid" type. They state the belief that the fluid type is more likely to occur near the metaphysis and the solid type in the shaft of a bone. They point out that a pathologic fracture occurring in the bone involved by a cyst

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⁴⁶ Krigsten W. M. and Phalen G. S. Localized Fibrocystic Disease of the Femur. A Report of Three Patients Treated by Curettage and Bone Graft. *Am J Surg* 67:12-23 (Feb) 1945.

always heals but that the cyst remains and another fracture may occur unless the cavity is packed with bone chips so that osteosynthesis takes place. The tibia and ilium were used as donor sites in their cases.

Goldthwait⁴⁷ describes a cyst of the sacrum that did not enlarge in thirty-five years. The patient was 44 years of age when she underwent an operation for removal of gallstones and uterine suspension in 1909. A cystic mass attached to the sacrum by a broad sessile base was noted in the hollow of the sacrum. Roentgenograms showed a large cyst which filled the sacrum, leaving only a shell of good bone at the periphery. The mass bulged posteriorly, as occurs in spondylolisthesis. The condition was treated conservatively with a lumbosacral support, and the patient got along well.

[ED NOTE—It is not uncommon to find cysts which have been present for many years without increase in size, but the cyst in the sacrum described by Goldthwait was present for a longer period than any that I know about. Pathologic fracture often is the first sign of a cyst. The cystic areas of decreased density with thinned and distended cortex are seen in the roentgenograms. The cysts commonly occur in young patients and are usually correctly diagnosed. I am convinced that when any doubt exists concerning such a lesion and fracture is imminent excision, biopsy and packing of the cavity with bone chips should be performed. The ilium or tibia provides excellent material for this.]

Metabolic Lesions—Hand-Schüller-Christian Disease. Schairer⁴⁸ adds a report of 2 cases of eosinophilic granuloma to his cases reported in 1938. The first case was that of a girl 13 years of age in whom the tumor was located in the parietal bone and was removed surgically. The microscopic picture was typical, and recovery was uneventful. No evidence of recurrence was found two years later. There was no history of trauma in this case. The second case was that of a girl aged 4 years who had a similar tumor in the frontal bone.

The author also presents a summary of 15 cases reported in the literature, a macroscopic and microscopic description of the tumors and a discussion of prognosis and etiology.

Engelbreth-Holm, Teilum and Christensen⁴⁹ report 5 cases of so-called eosinophilic granuloma of bone in children 2 to 9 years of age. Clinically and morphologically a gradual transition to the fully developed Schüller-Christian syndrome was observed in these cases. Clinically the

47 Goldthwait, J. E. A Case of Cyst of the Sacrum with No Increase After Thirty Years. *J. Bone & Joint Surg.* **27** 160-161 (Jan.) 1945.

48 Schairer, E. Osteomyelitis mit eosinophiler Reaktion (eosinophiles Granulom des Knochens), *Deutsche Ztschr. f. Chir.* **258** 637-649, 1944.

49 Engelbreth-Holm, J., Teilum, G. and Christensen, E. Eosinophil Granuloma of Bone—Schüller-Christian's Disease. *Acta med. Scandinav.* **118** 292-312 1944.

transition was from solitary eosinophilic granuloma to several foci to innumerable foci scattered throughout the skeletal system, together with diabetes insipidus disturbance of growth and roentgenographic changes in the lungs. In several cases in which the initial finding was a solitary granuloma continued observation revealed additional foci. The number of foci in the cases in the series increased with the period of observation. Morphologically, transitions were demonstrated from the lipid-free eosinophilic granuloma through granuloma with beginning lipid phagocytosis with Touton giant cells to entirely xanthomatous tissue. Eosinophilic granuloma no longer can be considered nosologically as an entity but must be considered as a not uncommon clinical monosymptomatic form of Hand-Schuller-Christian's disease, which often heals without becoming generalized. The histologic changes in these cases correspond exactly with the various histogenetic phases of Hand-Schuller-Christian's disease including (1) the hyperplastic proliferative phase, (2) the granuloma phase (3) the xanthoma phase and (4) the fibrous or healing phase. American writers have laid stress on differentiation of solitary eosinophilic granuloma from Hand-Schuller-Christian's disease, while German writers have emphasized the primary granulomatous nature of Hand-Schuller-Christian's disease but seem unacquainted with the clinical picture of solitary eosinophilic granuloma of bone. Ahlstrom and Welin in Sweden, in 1943, were the first to suggest that the two were related. In some cases roentgen therapy and in others surgical therapy yielded good results. In still others no treatment seemed effective.

[**ED. NOTE**—The two foregoing reports add to the literature 7 cases of Hand-Schuller-Christian's disease, or the so-called eosinophilic granuloma in children. This is an extremely rare disease of bones. These reports of clinical findings together with the microscopic and macroscopic studies add to knowledge of the disease so that accurate diagnosis can be made and removal of the tumor carried out. Roentgen therapy may be a useful adjunct to treatment. As more and more of these cases are encountered and the microscopic and macroscopic changes are studied contributions are being made to the settlement of the question of transition forms. All cases of this disease should be reported.]

Benign Osteogenic Tumors—Osteoma Rankin²⁰ reports a case of a man 48 years of age in whom a slow-growing osteoma was present on the medial side of the lower part of the left femur, which caused impairment of circulation. The tumor had been present for thirteen years and had not increased in size during the last seven years but had gradually produced intermittent claudication of the calves of the legs after exercise. It had exhibited cyanosis, venous distention and absence of dorsalis

²⁰ RANKIN, P. M. Vascular Insufficiency of the Lower Extremity Due to Osteoma of the Femur. *Surgery* 17: 419-421 (March) 1945.

pedis and posterior tibial arterial pulsation. The roentgenogram revealed evidence of what later proved to be an osteoma of the medial lower part of the left femur with calcification of the femoral artery just proximal to the lesion. At operation it was found that the osteoma partially obstructed the femoral artery and vein at the outlet of the adductor canal. The vein was twice normal size below the obstruction. The arterial wall was calcified only in the portion just proximal to the obstruction. After the osteoma had been removed the patient obtained complete relief of the intermittent claudication and venous engorgement, but no change in arterial pulsation was observed.

[ED NOTE—This case reported by Rankin, is unusual in that it concerns an osteoma, a benign tumor which obtained sufficient size to cause obstruction of circulation in the leg. In this case the response to excision was favorable. In modern times osteomas are usually removed before they obtain a size sufficient to interfere with circulation.]

Fibroblastic Tumors—Fibrosarcoma. Haagensen and Stout⁵¹ review 95 previously reported cases and add 9 new ones. They state that synovial sarcoma is a rare, highly specialized form of malignant neoplasm of the extremities. In only 3 of the 104 cases did the patient obtain a five year cure. The tumor occurred in 3 males to every 2 females, and the average age of the patients was 32 years. The first symptom was pain, and nearly half of the tumors were located at the knee although they have been reported from almost every joint in the extremities. The patients were treated by radical high amputation and dissection of the regional glands. Metastasis usually occurred by means of the blood and the lungs were the most frequent site of metastatic involvement, although regional glands were involved occasionally.

Murray, Stout and Pogogeff⁵² report that cultured tissue of synoviomias and normal synovia revealed the synovial cell as a specific type of cell, capable of considerable polymorphism. They further report that in tissue cultures of synovial sarcomas two types of cell and habits of growth prevail, although the distinction is less sharp in the tissue culture than it is in vivo. Histologic sections showed that two morphologically distinct types of cell coexist and display cancerous properties. In this respect synovioma exhibits certain similarities to the mesothelioma.

[ED NOTE—I have included synovial lesions in the fibrosarcoma group. It is my opinion that radical treatment is the method of choice in the majority of cases.]

51 Haagensen C D and Stout, A P. Synovial Sarcoma. *Ann Surg* **120** 826-842 (Dec.) 1944.

52 Murray M R Stout A P and Pogogeff I A. Synovial Sarcoma and Normal Synovial Tissue Cultivated in Vitro. *Ann Surg* **120** 843-851 (Dec.) 1944.

Giant Cell Tumors—Hughes⁵³ reports a case of giant cell tumor of the patella of a man 20 years of age. The patella had been enlarged for two and a half years after the patient was injured while playing football. Pain had developed after a blow across the knee received just prior to examination. The roentgenographic diagnosis was fibrocystic disease or giant cell tumor. The patella was excised, and the pathologist reported that the growth was a giant cell tumor. Recovery was uneventful.

Roemer⁵⁴ also reports a case of benign giant cell tumor of the patella. His patient was a man 28 years old whose knee had supposedly been injured. Roentgenographic examination disclosed a cystic defect of the patella. The upper half of the patella was excised, and the pathologic report stated that the lesion was a benign giant cell tumor.

Present⁵⁵ reports a case of subperiosteal tumor that developed two months after an injury. Tenderness was present, and supination of the left forearm was limited. Roentgenographic examination revealed a rounded, faintly calcified mass, 5 cm in length, which rested on a crater-like excoriation in the upper end of the right radius (questionable calcified hematoma). At operation an encapsulated tumor containing a mass of fleshy red material was removed. Pathologic examination showed that the tumor was composed of fibrous-appearing osteoid tissue with many giant cells and many pigment-laden macrophages (old hemorrhage).

[ED. NOTE—This condition, which probably resulted from ossification of a subperiosteal hematoma after injury, with pain and limited supination, gives a history suggestive of tennis elbow and demonstrates the value of roentgenographic study.]

Ribeiro⁵⁶ defines myeloplasmas and suggests that they might originate in (1) myeloplaxes, (2) small mesenchymal cells, (3) lipid or xanthomatous cells or (4) "conjuncto-vascular structures." He brings up the questions of whether these can be considered to be tumors in the strict biologic sense and of whether they are of the same nature as giant cell tumor of the tendon sheaths. He describes the symptoms and clinical types and advocates treatment by means of simple curettage after biopsy and diagnosis. His opinion is that amputation and resection are indicated rarely, and he describes in detail a case of a girl

⁵³ Hughes I. E. A Giant Cell Tumor of the Patella, *Australian & New Zealand J. Surg.* **14** 196 (Jan.) 1945.

⁵⁴ Roemer F. I. Benign Giant Cell Tumor of the Patella. *Am. J. Surg.* **67** 763-766 (March) 1945.

⁵⁵ Present J. J. So Called Subperiosteal Giant Cell Tumor. *Radiology* **41** 77-79 (Jan.) 1945.

⁵⁶ Ribeiro T. Os tumores de mieloplaxes dos ossos longos e a sua cura pela curetagem. *Rev. de pat. cir. traumatol. e ortop.* **1** 181-204 (Sept.) 1944.

18 years of age in whom amputation was avoided by the use of osteoperiosteal grafts after curettage. The roentgenogram in this case revealed a cavity 4.5 by 3 by 2 cm in the metaphysis of the femur and tip of the internal condyle. It was multilocular.

Jansson⁵⁷ presents a report of ten to twelve year cures in 4 cases of giant cell tumor treated by roentgen irradiation only. The lesions were located in the lower end of the femur or the radius. The patients were between the ages of 20 and 33 years. He states that low dosage of roentgen rays (500 to 1,000 r) given every second month until distinct ossification appears (three to four months) provides adequate treatment. He notes that after irradiation an initial period of increasing osteoclasia occurs before healing begins. One patient was cured by one dose of 600 r. In the past, bad results (dermatitis and ulcers) have been due to heavy dosage for this benign tumor. He expresses the opinion that the tumor recurs less frequently after irradiation than after curettage.

Hilton⁵⁸ presents 3 cases of giant cell tumor in which healing and recalcification occurred after roentgen therapy. Follow-up information was received from 1 patient for seven years and from another for eleven years. In 2 cases a diagnosis of sarcoma had been made elsewhere prior to treatment. Periosteal lifting and absorption of a large part of the cortex were evident on roentgenologic examination. The first evidence of healing after roentgen therapy was the reappearance or increase of the trabeculae. Hilton agrees with Jansson that the osteolytic type of giant cell tumor is only a more advanced form of the trabeculated type. After irradiation, in the initial period the tumor temporarily grows larger and more osteolytic and the bone is prone to fracture (one fracture in this series at the time of the report). This is followed by a period of healing. This author favors irradiation rather than surgical treatment of osteoclastomas.

Langenskiöld⁵⁹ states that giant cell tumors and ossifying hematomas are benign lesions which are oftenest incorrectly diagnosed as malignant lesions. He stresses the need for avoidance of unnecessary and useless amputations in cases of benign tumors, as well as the need for early treatment of patients with true osteosarcoma. He presents roentgenograms and details of 2 cases of giant cell tumor in which treatment consisted in scraping, insertion of 10 per cent solution of formaldehyde and then insertion of bone grafts. This author aligns himself with Broca

57 Jansson G. Roentgen Treatment and Course of Cure of Giant Cell Tumour in Osseous System (10-12 Years' Cure), *Acta radiol* 25: 569-579, 1944.

58 Hilton, G. Radiotherapy in Osteoclastoma, *Lancet* 1: 110-112 (Jan 27) 1945.

59 Langenskiöld F. Ueber Osteosarkomverdächtige gutartige Erkrankungen. *Acta chir. Scandinav* 87: 223-235, 1942.

and Foster and others who think that osteogenic sarcoma has a worse prognosis than is indicated in the literature and that apparent cures after radical operations are explained mainly by mistaken diagnosis

Sacerdote de Lustig and Schajowicz⁶⁰ state that in cultures of the general group of giant cell tumors of bone the fibroblasts were more or less similar and the large giant cells persisted for a considerable period. Multinucleated cells were present at all times throughout the entire study of these cultures and new giant cells were not formed. Due to the absolute absence of mitotic figures, these authors state that the cell division is amitotic. In the fragments of tissue examined great numbers of giant cells were observed in spite of the lack of osteoid and osseous tissue. This speaks against osteoclastic function of the giant cells. The authors are of the opinion that this tumor should not be considered to arise from osteoclasts.

Meyerding⁶¹ presents a series of 40 cases of benign giant cell tumors treated by resection or excision and bone grafting. These cases were encountered in a period of thirty-one years, 1913 to 1943 inclusive. He reviews the history, the clinical, roentgenographic and microscopic findings and the follow-up data in all 40 cases. The diagnosis of benign giant cell tumor was confirmed by microscopic reexamination of tissue in all these cases. Massive resection and excision by curettage and cauterization appear to be safe methods of eradicating the tumor. The resultant cavities have been filled with autogenous bone, which stimulates rapid formation of bone, lessens the danger of collapse from fracture and tends to prevent deformity and disability. Meyerding expresses the opinion that excision of the tumor with bone grafting is a safe procedure in properly selected cases and that it tends to prevent deformity and disability. Illustrations show the distribution of the lesions in the skeleton. He presents 8 cases with roentgenographic studies.

[En Note.—The number of papers on giant cell tumor of bone illustrates the continued interest of the medical profession in this group of tumors. Treatment depends on the type, size and correct diagnosis of the lesion. Considerable difference of opinion exists as to the value of microscopic and roentgenologic diagnosis. I personally prefer that the roentgenographic diagnosis be confirmed by an expert pathologist, as the so-called clinical and roentgenologic features sometimes prove untrustworthy. If it is assumed that the roentgenologic diagnosis of giant cell tumor is correct and that the lesion may be cured by roentgen

(60) Sacerdote de Lustig E. and Schajowicz F. Cultivo de tejido de tumor de células gigantes de los huesos. contribucion a la histogenesis de la célula gigante. *Revista de Patología y Traumatología* **14** 134-151 (Oct.) 1944.

(61) Meyerding H. W. Treatment of Benign Giant Cell Tumors by Resection and Bone Grafting. *J. Bone & Joint Surg.* **27** 196-206 (April) 1945.

therapy, the question arises of whether it is best to treat all tumors by roentgen therapy or whether excision and bone graft are wise in certain cases in which the lesion is situated so that they may be performed with a minimal loss of time and expense to the patient

In none of the papers cited thus far was a case of malignant giant cell tumor reported. However, Phemister, whose paper is reported in the section on "malignant osteogenic sarcoma," includes 1 case. I have reported a series of malignant giant cell tumors, and in the nomenclature I have divided the giant cell lesions of bone into the benign giant cell tumor and malignant giant cell sarcoma. If these two terms are adhered to there will be less confusion concerning the diagnosis, prognosis and proper treatment of the patients. I think that it is impossible to distinguish the benign giant cell lesion from the malignant giant cell sarcoma by roentgenographic examination alone.]

Vascular Tumors—Pohle and Clark⁶² report a case of multiple hemangiomas involving the skin, brain, vertebrae, ribs, long bones of the extremities and the pelvis, in which the patient responded well to roentgen therapy. The widespread lesions of the bones recalcified or regressed. The total observation period in the case was seven and a half years.

Brunner⁶³ discusses the diagnostic difficulties encountered in cases of Ewing's sarcoma and reports 5 of his own cases. The lesions in the 5 cases were located in the humerus, tibia, femur, tenth rib and fifth cervical vertebra. The ages of the patients varied from 10 to 32 years. It is Brunner's opinion that only on rare occasions is it possible to distinguish Ewing's sarcoma from osteomyelitis, especially if biopsy is not performed. This differentiation is especially difficult when the lesion is located in the vertebrae and the flat bones. The author expresses the opinion that the therapeutic test in which deep roentgen rays are used is not decisive, that the roentgenologic features are not diagnostic or that the characteristic periosteal reaction is not a reliable sign. Based on the roentgenograms made early in the course of the disease, the diagnosis usually was chronic osteomyelitis, and only after repeated roentgenologic examination at intervals of three to four weeks was the presence of a malignant lesion suspected. In the majority of cases the blood picture was normal. Slight leukocytosis occurred only in 1 case. The sedimentation rate was considerably elevated in 2 of the cases and slightly in 1. Decided elevation of temperature was not

62 Pohle, E. A. and Clark, E. A. Multiple Cavernous Hemangiomas of the Skin, Brain and Skeleton. Report of Case Treated by Roentgen Rays and Observed for 7½ Years. *Urol. & Cutan. Rev.* 49: 283-287 (May) 1945.

63 Brunner, W. Das Ewing-Sarkom (Retikulosarkom des Knochenmarks) mit besonderer Berücksichtigung seiner Differentialdiagnose auf Grund von 5 eigenen Beobachtungen. *Deutsche Ztschr. f. Chir.* 258: 540 1944.

present. Although a single symptom cannot be pathognomonic, the early pain and especially the night pain are the best leads. Only 1 of the 5 patients died. In that case the lesion was in the tibia. The patient with the lesion of the rib was treated by radical excision of the tumor followed by irradiation, the other 3 patients received irradiation only. When roentgen therapy was given, swelling of soft tissue and pain disappeared within a few weeks. Restoration of the bone, however, took considerably more time.

Reeves⁶⁴ reports 2 cases, 1 of his own and the 1 of Archer, in which primary round cell tumors resembling Ewing's sarcoma were present in the mandible and rib respectively. In each case roentgenographic evidence suggested that pulmonary metastatic lesions were apparently cured by irradiation. The primary tumors were eradicated by excision and irradiation therapy. The first patient, a girl 9 years of age, had a lump in the left mandible, which was removed by excision, and roentgen therapy was given. The growth recurred several times (1936, 1938 and 1941) and was treated surgically (excision of the lymph nodes in the neck because of metastasis and removal of the left mandible in 1941), and further irradiation was given. In 1942 multiple pulmonary metastatic lesions were given deep roentgen therapy and cleared completely. At an examination in 1944, no metastatic lesions were present in the lungs and the patient was apparently in good health. Archer's patient was a girl 6 years of age who was given deep roentgen therapy for multiple pulmonary metastatic lesions from a lesion which was apparently primary in the right sixth rib (Biopsy of the rib had revealed sarcoma). In March 1943, eleven years later examination showed no evidence of the lesion nor any symptoms. The lungs were free of involvement. Thus, in 2 cases of seemingly hopeless conditions cures apparently were obtained.

[ED NOTE—Vascular neoplasms of bone are more responsive to roentgen therapy than are other tumors of bone, and successful roentgen therapy is practically diagnostic of Ewing's sarcoma in cases in which other findings support the diagnosis. A lesion of this type may disappear entirely, and the patient may remain in good health for many years. I have reported 1 case, that of a girl who was 11 years old on her first admission, in which treatment consisted in roentgen therapy and administration of Coley's toxins. She was alive and well more than seventeen years after treatment. The lesion was located in the left femur, and biopsy revealed that it was an endothelioma. If it is possible, it is preferable to excise and irradiate some vascular tumors. However, some are of such size and so located that roentgen therapy is the only practical form of treatment. It should be remembered that these

64 Reeves, R. J. Round Cell Tumor of Bone Resembling Ewing's Tumor. *South M J* 38 302-306 (May) 1945.

small round cell lesions of the Ewing type are not infrequently interpreted to be inflammatory, or a diagnosis of osteomyelitis is made even after operation and microscopic examination]

Malignant Osteogenic Sarcoma —Phemister ⁶⁵ reports 2 cases of sarcoma of the femur. The first patient, a man 26 years of age, underwent resection of part of the lower part of the femur and upper end of the tibia. The diagnosis was malignant giant cell tumor. A graft 11 inches (27.9 cm) in length, from the tibia was cut in two and placed so that it bridged the gap left when the sarcoma was removed, the grafts were placed in both the coronal and the sagittal plane and were fixed above and below by means of threaded wires. The second patient was a girl 11 years of age who had a recurrent cartilaginous tumor in the shaft of the lower part of the right femur, which was considered to be a chondrosarcoma of low grade. Resection of about 6 inches (15.2 cm) of the shaft of the femur was performed, the knee joint being left intact. Tibial grafts were inserted as described in the first case. Excellent results were obtained in both cases, both grafts were gradually transformed into tubular bone which resembled the missing part. Both patients are living and well approximately four years after operation.

Sarasin ⁶⁶ emphasizes the complexity of roentgenologic images of tumors of bone, which renders diagnosis difficult, and the great importance of careful clinical examination and of the history. He describes a case in which the patient was a child. Three months after the patient had bronchopneumonia a hard swelling developed in the upper half of the left femur. Roentgenographic examination revealed destruction of bone in the upper third of the femur, the picture suggested the presence of sarcoma, and operation was advised. The child's mother, however, insisted that the swelling was the result of the injections given the child for the pneumonia, and a second roentgenographic examination revealed evidence of inflammation. Puncture yielded pus, and on culture Koch's bacilli were identified. In this case operation would have had fatal results. Sarasin emphasizes that differentiation of Brodie's abscess is impossible by roentgenographic examination and that biopsy is an important measure. He describes various types of sarcoma and is of the opinion that roentgen therapy plus operation is the treatment of choice and that Ewing's sarcoma is often present for long periods before diagnosis is made. He calls attention to the disproportion between the roentgenographic image and the microscopic extension of the tumor occasionally an enormous tumor will effect only slight roentgenologic changes. Sarasin also points out that histologic studies are important

65 Phemister, D. B. Rapid Repair of Defect of Femur by Massive Bone Grafts After Resection for Tumors. *Surg. Gynec. & Obst.* 80:120-127 (Feb.) 1945.

66 Sarasin, R. Les tumeurs osseuses: leur diagnostic et leur traitement. *Praxis* 33:530-534 (Jul. 27) 1944.

in identifying myeloplax tumors. He expresses the opinion that the tumors are benign. Surgical or roentgen therapy may be used but he states the belief that some of the lesions do not respond to treatment as readily as others and that if the cyst resolves with formation of slightly vascular bone tissue the course is longer. Even though myeloplax tumors are not malignant they should be treated as such because failure of an initial attempt will greatly impair the results of later treatment. If roentgen therapy produces no change the tumor probably is an atypical myeloplax tumor which is not radio-sensitive. It is his opinion that total extirpation is indicated and he reports 2 illustrative cases. The tumor may be transformed to sarcoma.

Metastatic Tumors—Cohn and Cohn⁶⁷ report 4 cases in which the patient had pain low in the back and was treated for sacroiliac strain by means of sacroiliac belts, diathermy, heat and other measures when the correct diagnosis was small primary carcinoma of the breast (proved microscopically) with skeletal metastasis. In 3 cases evidence of metastatic osseous lesions was found on initial roentgenographic examination, but in 1 of the 4 negative results were obtained until four months thereafter. They advised repeated roentgenograms. They discuss the route of metastasis by the way of Batson's mechanism through the valveless vertebral veins from the thoracodominant veins by coughing, straining, lifting and other means. They are of the opinion that breasts of all patients should be examined carefully for tumors especially when pain low in the back or pelvic pain is present, and that pain in the lower part of the back may be the first evidence of neoplastic disease.

Peck⁶⁸ reports 2 cases in which the patient had pain low in the back from metastatic prostatic carcinoma. After orchiectomy pain was relieved completely and roentgenographic evidence of healing of the metastatic lesions was observed. Reports in the literature of 300 cases of carcinoma of the prostate were reviewed. In 75 per cent of these 300 cases pain was relieved and the serum acid phosphatase level dropped, often within twenty-four hours after orchiectomy or administration of estrogen. Peck states that carcinoma of the prostate with metastasis is the only condition in which the level of serum acid phosphatase is high and quotes from the report of Dean and his associates as follows: "In their studies they used the Bodansky unit in which 0.7 unit was considered normal and any value over 1.0 was considered pathognomonic of metastases from carcinoma of the prostate. The normal alkaline phosphatase, using this method, is 1.5 to 5.0." Orthopedic surgeons must be constantly on the lookout for this condition in any man more than

67 Cohn T. D. and Cohn H. Low-Back Pain as the Presenting Symptom of Malignant Breast Tumors. *New England J. Med.* **232** 342-343 (March 22) 1945.

68 Peck R. I. The Treatment of Skeletal Metastases Secondary to Carcinoma of the Prostate. *J. A. M. A.* **127** 17-19 (Jan. 6) 1945.

50 years of age who has pain low in the back, and rectal examination as well as routine orthopedic examination should be made. When doubt exists after roentgenographic examination for evidence of metastasis, determination of the value for serum acid phosphatase will aid in the diagnosis and the results of later determinations will be indicative of the efficacy of treatment.

Dargent and Hutinel⁶⁹ describe the removal, by block dissection, of an atypical epithelioma of the right lobe of the thyroid. The superior thyroid vein was found to be invaded by the growth. Even though roentgenographic examination revealed malignant destruction of the fourth thoracic vertebra and the patient had paraplegia, operation was performed and roentgen therapy given. The patient gradually became able to walk after this. Follow-up information was obtained concerning this patient for two years. At last examination, the Babinski sign was still positive but motor function was good. The bone had not healed, as far as could be determined from the roentgenographic appearance. Evidently the tumor was extremely radiosensitive. These authors also cite the case of a woman who underwent surgical removal of the manubrium sterni for metastasis from an epithelioma of the urinary bladder. After she remained well for thirteen years, clavicular metastatic lesions were found.

Ringertz and Ehrner⁷⁰ report 2 cases of neurofibromatosis with sarcomatous degeneration. The first was a case of generalized neurofibromatosis in which the patient was a woman 52 years of age. A fibrosarcomatous tumor had been removed from the sciatic nerve on the right side when she was 21 years of age. Thirty-one years later the tumor recurred in both sciatic nerves, and death occurred five months after the second operation. Postmortem examination revealed fibrosarcoma of the thorax, liver, vertebrae and right arm. The second patient was the son of the first patient. He underwent operation at the age of 19 years for fibrosarcoma of the neck. Three years later the tumor recurred locally and rapidly increased in size in spite of intensive irradiation. The patient died of bronchopneumonia at the age of 24 years. This patient, who was apparently free from neurofibromas of the skin, appeared to have extensive neurofibromatosis of practically all the spinal nerves. Review of the literature showed that 105 proved cases of neurofibromatosis with sarcomatous degeneration have been reported. Apparently sarcomatous changes occur in about 13 per cent of the

69 Dargent, M., and Hutinel, J. Epithelioma atypique du corps thyroïde. Métastase vertébrale et paraplegie. Lobectomie thyroïdienne élargie et radiothérapie. Resultat au bout de 2 ans, *Lyons chir* 37: 374-379, 1941-1942.

70 Ringertz, N., and Ehrner, L. Ueber Sarkombildung bei Recklinghausenschr Neurofibromatose (mit Beschreibung zweier neuer Fälle), *Ztschr f. d. ges Neurol u. Psychiat* 176: 297, 1943.

cases of neurofibromatosis. These sarcomatous changes show a high frequency of location in the nerve plexuses of the extremities. Sarcomatous degeneration rarely occurs in cutaneous neurofibromas. The authors state that operation in cases of neurofibromatosis tends to produce a malignant reaction. Metastasis, especially to the lungs, pleura, liver and skeleton, occurs rather frequently.

Trafton and Perkin⁷¹ present a report correlating the results of nine hundred and twenty-five determinations of the level of serum acid phosphatase by the modified Bodansky method at the Lahey Clinic. They bring out that acid phosphatase is present in significant amounts only in the prostate gland and that the level in the serum is abnormally high only in cases of carcinoma of the prostate with metastasis. When the level of serum acid phosphatase is 0.8 to 1 unit per hundred cubic centimeters and the level of serum alkaline phosphatase is normal, the presence of carcinoma of the prostate with metastasis is indicated. Values of 1.2 or more units are pathognomonic. The authors consider the average normal values in males to be 0.5 unit and in females 0.42 unit. The level of serum acid phosphatase was elevated in 24 of 50 cases of prostatic carcinoma, the level of alkaline phosphatase in 22 and the levels of both in 17. In 81 per cent of the cases in which metastasis to bone had occurred an initial elevation was noted. The highest value was 34 units. The level of serum acid phosphatase was elevated in 3 cases before roentgenograms revealed metastasis. Castration resulted in a pronounced fall in the serum acid phosphatase level in 24 cases and the level did not rise for from one to three years. Clinical improvement occurred. The determination of the phosphatase level is of diagnostic and prognostic value and is a guide to endocrine therapy.

[ED. NOTE—The reports of these authors emphasize the importance of thorough study of the history and of the clinical and laboratory observations and roentgenograms in all cases of unexplained pain, since metastasis may be the principal cause of pain.]

Classification of Bone Tumors—MacCarty⁷² presents his theory of origin of neoplastic tumors evolving from hemorrhage in bone marrow or under the periosteum. He states that many, if not all, osteogenic sarcomas if viewed early would present the picture of giant cell tumor resulting from hemorrhage. He considers that a second group of bone tumors arises from endothelial cells and a third group from the bone

71 Trafton H. and Perkin H. J. The Clinical Significance of Serum Acid Phosphatase with Especial Reference to Carcinoma of the Prostate Gland. *Lahey Clin. Bull.* 4: 59-63 (Oct.) 1944.

72 MacCarty W. C., Sr. The Genesis, Nomenclature and Classification of Bone Tumors. In Thomson J. E. M. The American Academy of Orthopaedic Surgeons Presents Lectures on Peace and War Orthopedic Surgery. Ann Arbor, Mich. Edwards Bros., Inc. 1945, pp. 248-256.

marrow cells. On that basis he proposes a classification based on (1) tumors composed of adult differentiated tissue cells, (2) tumors composed of young regenerative or partially differentiated cells, (3) tumors composed of mixed cells which may or may not be differentiated and (4) tumors composed of undifferentiated cells. He states the belief that the primitive cell of bone is probably an endothelial cell which is closely related to fibroblasts.

Miscellaneous—Beard⁷³ reports his study of the effects of penicillin and choline on Emge sarcoma transplants in three groups of rats. Each rat in the first group (control) received two Emge sarcoma transplants. Each rat in the second group received the same type of transplants and in addition an injection of 2 cc. of a solution containing 333 Oxford units of penicillin daily. Each rat in the third group received the same type of transplants and 40 mg. of choline chloride daily in the drinking water. Beard states that penicillin and choline apparently caused a significant number of the tumor transplants to fail to grow, and the tumors that did grow were, on the whole, smaller when penicillin had been used. He feels that no conclusions are justified in regard to the number of takes and the slower growth of the tumors due to the many factors that may influence these characteristics of tumors.

[ED. NOTE—While no justifiable conclusions were reached in this study, such experiments should be continued, as it is possible that they may lead to discovery of a means of controlling or inhibiting the growth of malignant lesions.]

Gratzek, Holmstrom and Rigler⁷⁴ present a review of 1,363 cases in which malignant lesions of the pelvis were irradiated. They found 25 cases in which the patient had damage of bone that included aseptic necrosis, sclerosis, absorption and fractures. From 1936 to 1941 a high dose of irradiation was given in 568 cases, and bone sequelae developed in 32 per cent of this group. After repeated roentgenographic examinations it was concluded that pain preceded sclerosis and necrosis and that fractures occurred later. The time after irradiation before the damage was detected was between five months and five years. In 13 cases of this series the femoral neck was found to be fractured, and 55 cases in which this had occurred were reported in the literature up to 1941. Three cases of multiple fractures of the pubis, ischium, ilium and sacrum are reported in detail. In their study the authors found that in patients with postirradiative changes the lesions of bone healed readily.

73 Beard H. H. The Effect of Penicillin and Choline upon the Appearance, Growth and Disappearance of the Emge Sarcoma in Rats. *Exper. Med. & Surg.* 2: 286-289 (Nov.) 1944.

74 Gratzek F. R., Holmstrom E. G. and Rigler L. G. Post-Irradiation Bone Changes. *Am. J. Roentgenol.* 53: 62-76 (Jan.) 1945.

with the usual orthopedic treatment. They state that the lesions result from irradiation fibrosis and obliteration of the blood supply to the bone, and they warn physicians not to mistake these lesions for metastatic lesions and give more irradiation. Additional irradiation was given in 1 case, and damage was increased.

[ED. NOTE—These postirradiation changes in bone are of great importance and should be looked for in cases in which roentgen therapy has been given and fractures have occurred.]

(To Be Continued)

VITAMIN C IN GASTRIC RESECTION FOR PEPTIC ULCER

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ALTHOUGH the role of vitamin C in wound healing has long been known, its behavior during and after surgical operations was not realized until 1937, when it was shown¹ that operation or injury increased greatly the need for this vitamin. This was confirmed a few years later.² Moreover large concentrations of ascorbic acid are mobilized in areas of injury, an observation³ which may explain the increased needs. A second possible relationship between vitamin C and injury was suggested by its behavior in surgical shock. It was shown, for example, that large doses of vitamin C seem to have a beneficial therapeutic effect in experimental hemorrhage⁴ and traumatic shock⁵ even when there is no deficit. Other experiments⁶ showed that animals deficient in vitamin C were less able to resist the effects of injury on the peripheral circulation. While no specific clinical data are available, the statement has been made⁷ that the intravenous injection of large doses of vitamin C "produced astonishing recovery from severe postoperative shock."

The present observations were made on 2 vitamin C-deficient patients with duodenal ulcer subjected to gastric resection and add further data in support of the two relationships mentioned. The methods

These observations were made while the author was a Fellow in Thoracic Surgery, International Institute of Education, in the Department of Surgery, Washington University School of Medicine and Barnes Hospital, St. Louis

1 Lanman, T H, and Ingalls, T H. Vitamin C Deficiency and Wound Healing. An Experimental and Clinical Study, *Ann Surg* **105** 616, 1937
Lauber, H J. Ueber den Vitamin C-Stoffwechsel bei chirurgischen Erkrankungen und Eingriffen, *Arch f klin. Chir* **189** 282, 1937

2 Bourne, G H. Vitamin C and Repair of Injured Tissues *Lancet* **2** 661, 1942

3 Bartlett, M K., Jones, C M., and Ryan, A E. Vitamin C in Surgery, *Ann Surg* **111** 1, 1940, Vitamin C and Wound Healing, *New England J Med.* **226** 469, 1942

4 Stewart, C P., Learmonth, J R., and Pollock, G A. Intravenous Ascorbic Acid in Experimental Acute Haemorrhage, *Lancet* **1** 818, 1941

5 Ungar, G. Experimental Traumatic "Shock," *Lancet* **1** 421, 1943

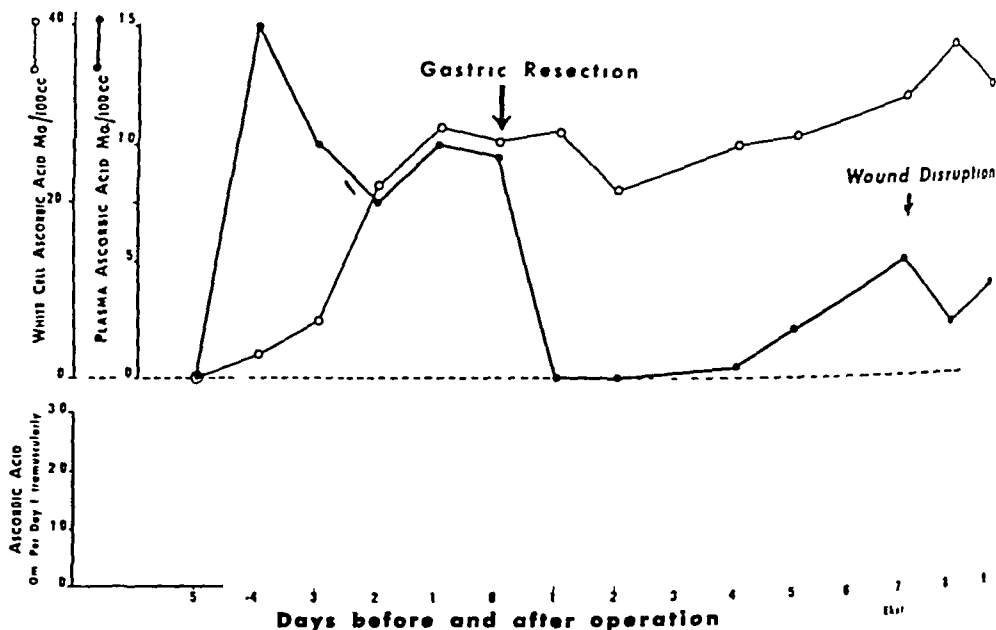
6 Schneider, E. Erfassbare Vitaminverlust und ihre Bedeutung fur das Knochensystem, *Arch f klin. Chir* **189** 288, 1937

7 Holmes, H N. Vitamin C in War, *Science* **96** 384, 1942

used in measuring vitamin C were based on the technic described by Mindlin and Butler⁸

REPORT OF CASES

CASE 1—B T, a 32 year old man, had had clinical and roentgenologic evidence of duodenal ulcer of sixteen years' duration, but at the time of admission he seemed in excellent nutritional condition and routine examinations were normal. He had been on a medical regimen which was presumed to be adequate, but his diet was found later to consist largely of milk and cream, with little or no fruit juices or fresh vegetables. A preliminary determination of the level of plasma vitamin C, which showed none present, was not available before operation, so no ascorbic acid was administered. On the morning of operation the plasma



Note the absence of any vitamin C in either white cells or plasma on admission and the rapid correction in the plasma and the slower correction in white cells following large (3 Gm daily) doses of vitamin C. Note, following operation the prompt fall in the plasma content without a corresponding fall in white cell level. On the seventh day, after removal of the skin sutures, it was obvious that no healing had occurred, for the wound edges separated spontaneously. The rest of the wound remained intact, which was probably due to the fact that the anterior sheath of the fascia had been approximated with interrupted stainless steel sutures. Eventually the skin healed, without infection.

was again examined, including also the white cells, neither showed vitamin C. At operation a large duodenal ulcer was easily demonstrated, the ulcer and part of the stomach were resected. During the procedure, the tissue was observed

⁸ Mindlin, R. L. and Butler, A. M. Determination of Ascorbic Acid in Plasma. Macromethod and Micromethod, *J. Biol. Chem.* 122: 673, 1938.

to be abnormally friable and capillary bleeding was unusually great. There was a progressive though moderate fall in blood pressure during the latter part of the operation. As the abdomen was being closed, however, there was a further fall in blood pressure and some depression in respiration, necessitating at one point artificial respiration. Most striking, however, was the evidence of peripheral circulatory collapse. The extremities were cold and cyanotic, and when one cut down on the peripheral veins they were found to be empty. The injection of plasma and whole blood had little influence on the peripheral circulation or on the level of the blood pressure. At a time when the patient seemed almost moribund the results of the ascorbic acid determinations became known, and because of them 2 Gm of vitamin C was injected intravenously. Within a few minutes the blood pressure rose and soon reached normal. The color of the extremities improved, and the other evidence of circulatory impairment quickly disappeared. Large amounts of the vitamin were given during the next two days, and on the third day the level of plasma vitamin C had risen to 24 mg per hundred cubic centimeters. The recovery of the patient was thereafter uneventful, and he left the hospital on the tenth postoperative day. Microscopic section of the portion of the stomach removed showed a pronounced intracellular edema not unlike that seen in scurvy.

CASE 2—E. E., a 42 year old man, was admitted to Barnes Hospital with a history of persistent vomiting and moderate loss of weight. The present episode was one of a series during many years. A diagnosis of duodenal ulcer had been made many times in the past, on the basis of roentgenologic studies after the ingestion of a barium meal. On admission there was evidence of complete pyloric obstruction and of some bleeding, as shown by the passage of several tarry stools. A decision was made to do a gastric resection, and the patient was given pre-operative preparation with transfusions, parenteral alimentation and gastric aspiration. At operation a duodenal ulcer was found, and it was resected with a large part of the stomach. Evidence of postoperative pneumonia developed within twenty-four hours but responded to chemotherapy. Removal of the sutures was followed by a gaping skin wound, which gradually filled in and healed by secondary intention. Recovery was eventually complete.

The observations on the vitamin C content of his plasma and white cells are graphically shown in the accompanying figure, the legend of which is explanatory.

COMMENT

The first case described herein was remarkable in that a total absence of vitamin C in the blood and white cells, confirmed by a microscopic appearance suggesting scurvy in excised tissue, was associated with no clinical manifestations on thorough physical and ordinary laboratory examinations. That this deficiency made the patient more susceptible to the pronounced circulatory impairment, which was observed following the gastric resection, was indicated by the prompt improvement of shock following the intravenous injection of a large dose (2 Gm) of the vitamin. One such observation cannot be taken as more than merely suggestive, further studies would obviously seem worth while.

The second case showed that a daily dose of 200 mg of vitamin C after operation did not prevent a total disappearance of the vitamin from

the plasma, even though the tissues had apparently been saturated thoroughly before operation. This may have occurred in the absence of complications but was presumably aggravated by the postoperative pneumonia. More significant than this was the obvious failure of wound healing, even though the concentration in the white cells remained high. This would suggest that a low or zero level of plasma ascorbic acid should not be looked on as harmless and that a sufficient amount should be given after operation in order to maintain a high plasma level. As a result of this experience at least 1 Gm. of ascorbic acid is now given as routine following gastric resection. Similar findings were observed after thoracic operations.⁹ Whether such a dose is sufficient to prevent disappearance of the vitamin from the plasma after operation awaits further investigation.

SUMMARY

Two patients with duodenal ulcer were subjected to gastric resection. One, with a total, though unsuspected, absence of ascorbic acid in white cells and plasma, without clinical manifestations and uncorrected by preoperative therapy, exhibited severe surgical shock during operation, which seemed to respond promptly to the intravenous injection of 2 Gm. of the vitamin. The other, with a known absence of ascorbic acid in plasma and white cells, completely corrected before operation, exhibited after operation a fall to zero in the plasma level, with no corresponding fall in the white cell level in spite of the daily injection of 200 mg. of the vitamin, on removal of stitches on the seventh postoperative day, the wound showed no evidence of healing.

⁹ Zerbini, E. de J. Importance of Ascorbic Acid (Vitamin C) in Chest Surgery. *J. Thoracic Surg.* 14: 309, 1945.

INCISED WOUNDS OF THE HEAD INFLICTED BY BAYONETS

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A REVIEW of recent and older medical literature discloses that the occurrence of bayonet wounds of the head is rather infrequent if not rare. I had an opportunity to observe and treat 5 patients who had penetrating craniocerebral wounds incurred with bayonets. Because of the peculiarities as well as the rarity of this type of head wound, the 5 cases are recorded herein together with a resume of the history of the bayonet and a review of the medical literature pertaining to such injuries.

HISTORICAL ASPECTS

Bayonet—The infliction and treatment of incised wounds of the head from sharp-edged weapons have been of prime importance to man's existence since prehistoric times. Although in ancient times swords and spears were common implements of warfare, in more recent centuries the bayonet has taken their place and now it remains the one sharp-edged weapon of common usage by foot soldiers. The origin of the bayonet is not entirely clear. Tradition has it that the bayonet was invented near Bayonne, France, in the latter part of the sixteenth century. The story runs that the first use of the bayonet in warfare occurred in a battle between Basque peasants and a band of Spanish smugglers which took place in a small hamlet in the environs of that city in the early part of the seventeenth century, the farmers, having exhausted their ammunition, defeated their opponents by charging them with long knives fastened in the muzzles of their muskets. As Akerman¹ has pointed out, this version lacks authenticity, "and the relation begets suspicion that the mere similarity of name has laid the foundation of the supposed connection of the bayonet with Bayonne." The first use of the bayonet which historically appears to be more nearly accurate seems to have been made by the elder Puysegur, a native of Bayonne, who equipped his troops for the battle of Ypres (1647) with an early model of the bayonet. He employed a steel blade fixed to a wooden haft and fitted into the barrel of the musket. The result was a plug bayonet (fig 1)². From the evidence in records of court martials involving some English soldiers

* Dr Abbott has now returned to civilian status, Rochester, Minnesota

¹ Akerman, J. Y. Notes on the Origin and History of the Bayonet, *Archaeologia* 38 (pt 2) 422-431, 1863

(Footnotes continued on next page)

at Tangier in 1663 and 1664, it has been established that the English had equipped their soldiers with plug bayonets. In 1671 plug bayonets were issued to a French regiment of fusiliers, and in the following year (1672) they were issued to part of an English dragoon regiment, although they were withdrawn in 1674. However, the English are known to have issued plug bayonets to the Royal Fusiliers when they were raised in 1685 and to the Foot Guards in 1686. It is said that the English defeat at Killiecrankie in 1689 was due (among other things) to the use of the plug bayonet. About the year 1678 the ring bayonet was introduced, thus allowing the use of the musket while the bayonet was attached.² In spite of the earlier invention of the ring bayonet it was not until about 1690 that General Mackay introduced this new type and claimed it for his own invention. In the same year, after the battle of Flurus (1690) the French tried a poorly fitting socket, or zig-zag, bayonet, but Louis XIV refused to adopt it. In 1697, after the battle of Ryswick the English and Germans abolished the pike and officially introduced these bayonets, but the French did not issue them until 1783. From that time onward the bayonet became, with the musket and other firearms, the typical weapon of the infantry. Various changes in the shape and length of the blade of the ring bayonet took place in the eighteenth century, but it was not until 1805 that the spring clip device for attaching the bayonet to the gun was introduced by Sir John Moore. This device, with some modifications, is still in use. There were many changes in the blade of the bayonet from the earlier

2 (a) de Puysegur, J. *Les memoires de Messire Jacques de Chastenet Chevalier, Seigneur de Puysegur*, ed 2, Paris, Charles-Ant Jombert, 1747, vol 2, p 306. (b) Wintringham, T. *Story of Weapons and Tactics, from Trov to Stalingrad*, Boston, Houghton Mifflin Company, 1943, pp 114-115. (c) Harford in his "English Military Discipline" (1680), observed, "The Bayonet is much of the same length as the Pomard (12 or 13 inches), it hath neither Guard nor Handle, but only a Haft of Wood Eight or Nine Inches long. The Blade is Sharp-pointed, and two edged a foot in length, and a large inch in breadth" (Harford, R. *English Military Discipline, or, The Way and Method of Exercising Horse and Foot, According to the Practise of This Present Time, with a Treatment of all Sorts of Arms and Engines of War, of Fireworks, Ensigns and Other Military Instruments, with Ancient and Modern*, London Privately printed, 1680, p 13).

3 The *Encyclopaedia Britannica* gives credit to M de Puysegur for introducing the ring bayonet. However, Akerman states "Puysegur mentions that he had seen before the Peace of Nijmegen (1678) a regiment which was armed with swords without guards but furnished with brass rings, one at the blade and the handle, the other at the pommel." Recently Wintringham^{2b} has given credit to Vauban for introducing the ring bayonet, however, he dated this as of 1687, which, of course, is later than Puysegur's observation, and scrutiny of the date suggests the possibility of transposition of figures (Bayonet, in *Encyclopaedia Britannica*, ed 14, New York, Encyclopaedia Britannica Company, 1937, vol 3, pp 242-243).

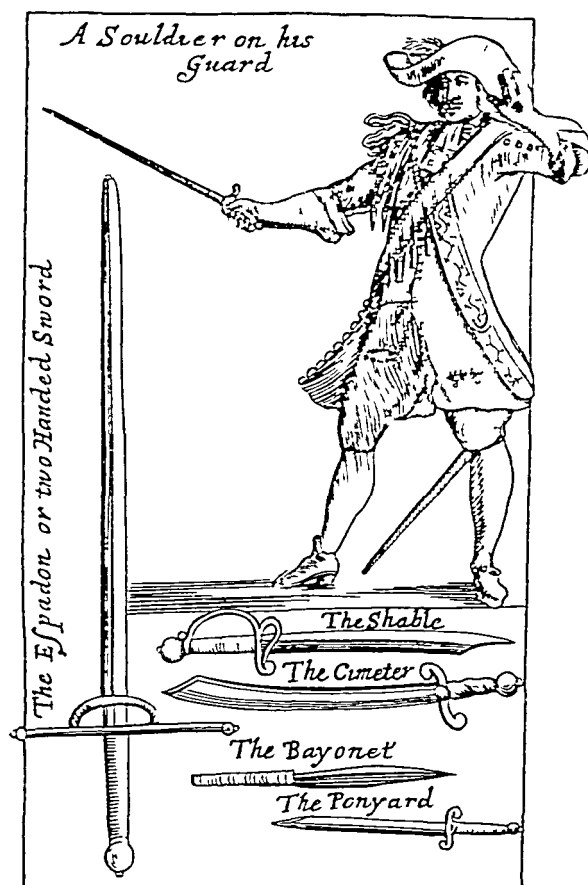


Fig 1—An illustration of seventeenth century sharp-edged weapons, depicting an early model of the plug bayonet (taken from Harford's "English Military Discipline," 1680)

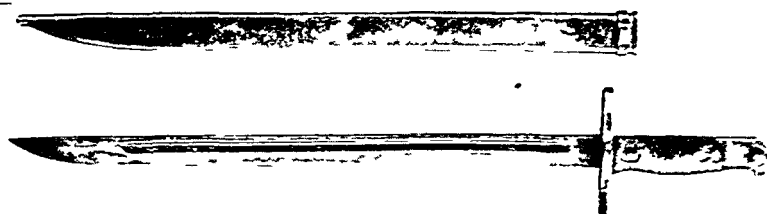


Fig 2—A Japanese single-edged bayonet which is triangular in cross section. The weapon is 15 inches long and weighs $15\frac{1}{4}$ ounces

knife and dagger blade types. Among these, the triangular bayonet, so-called because the cross section of the blade had that shape, became popular, particularly with the British and Americans. Later, however, with the introduction of the magazine rifle, the British changed to the plain sword bayonet, which they used in World War I. In 1928 they changed to the 8 inch (20 cm) pike blade. This type is cruciform in section and is no thicker than a lead pencil. In 1905 the United States forsook the triangular bayonet used in the Civil War for a 16 inch (40 cm) blade with the front edge sharpened throughout its length and the back edge sharpened for a distance of 5 inches (12 cm) from the point.

The German bayonet has been the same as that in use before World War I. That is, it is a sword bayonet 37.9 cm (about 15 inches) in length and 1 pound, 4 ounces (567 Gm) in weight. The Italian army used a dagger-shaped bayonet 11¾ inches (30 cm) long, weighing 12 ounces (340 Gm). The French army replaced its long, cross section sword bayonet by a shorter one, with a 15¾ inch (40 cm) blade, an action which, like the change made by the British, indicated that the utility of the bayonet in war is not so great as it was before World War I.

The Japanese have used a straight, single-edged weapon (triangular type) 15 inches (38 cm) long and 15¼ ounces (431 Gm) in weight (fig 2). It is probably significant that training with the bayonet occupied a much larger portion of time in the Japanese army than in other armies.

MEDICAL HISTORY

Although military surgeons of the seventeenth and eighteenth centuries must have cared for many bayonet wounds of the head, it was not until the nineteenth century that much attention was given to cranial wounds incurred with bayonets. Hennen⁴ gave such wounds prime importance in his classification of war injuries of the head. His classification was "First, simple bayonet and spike thrust and sabre cuts, second, the same complicated with fractures, third, simple gunshot wounds and contusions without fractures, fourth, the same complicated with fractures and with lodgement of extraneous bodies."

In spite of the attention Hennen gave to bayonet wounds of the head, he noted that "perforations of bone (skull) from bayonet thrust are rare, generally fatal." From the medical history of the Crimean War, it is of interest to note that the British army suffered 11,900 casualties, but that there were only seventy-six bayonet wounds, which caused seven deaths. Even if it were assumed that the same proportion obtained among those killed (2,700), the total number of cases of bayonet wounds

4 Hennen, J. Principles of Military Surgery, ed 1, Philadelphia, Carey & Lea 1830, p 229

would be only 93 Just how many of the bayonet wounds involved the head is not reported Guthrie,⁵ however, stated that they were rare⁶ He attributed the rarity of bayonet wounds of the head to the fact that thrusts with the bayonet were usually made toward the chest and abdomen and not toward the much less vulnerable head Guthrie further stated "A great delusion is cherished in Great Britain on the subject of the bayonet—a sort of monomania very gratifying to the national vanity, but not quite in accordance with matter of fact Opposing regiments when formed in line and charging with fixed bayonets, never meet and struggle hand to hand and foot to foot, and this for the very best possible reason, that one side turns round and runs away as soon as the other comes close enough to do mischief" The same might be said of present day warfare, with the difference that automatic firearms usually incapacitate those charging with fixed bayonets

The infrequent occurrence of bayonet wounds of the head in warfare was further confirmed in the reports of casualties in the War of the Rebellion Although two hundred and eighty-two incised wounds of the scalp were caused by sharp-edged weapons other than the bayonet, only eighteen puncture wounds of the scalp incurred by bayonets were recorded⁸ Similarly, in contrast to forty-nine incised cranial fractures, there were only five puncture-fractures of the cranium caused by bayonets Lidell⁹ (1863) further confirmed these statistics when he stated, "The truth is, that wounds inflicted by the bayonet have been of comparatively rare occurrence in every war that has scourged the earth since the invention of the weapon," the Civil War being no exception Between the War of the Rebellion and World War I, only sporadic reports of cranial wounds caused by bayonets are found in the literature¹⁰

5 Guthrie, G J Commentaries on the Surgery of the War in Portugal, Spain, France, and the Netherlands, from the Battle of Rolicca in 1808, to That of Waterloo in 1815, with Additions Relating to Those in the Crimea in 1855 ed 6 Philadelphia, J B Lippincott & Co, 1862, p 38

6 In emphasizing the infrequent occurrence of bayonet wounds of the head, Guthrie noted that the siege of Sevastopol "furnished more opportunity for such wounds but there is no record of any bayonet wound of the head"

7 Guthrie, G J, cited by Bill,¹⁶ p 103

8 Otis, G A Surgical History, in The Medical and Surgical History of the War of the Rebellion (1861-65), ed 2, Washington, D C, Government Printing Office, 1875, vol 2, pt. 1, chap 1, sect. 1, pp 1-34

9 Lidell, J A Bayonet Wounds, with Cases, *Am M Times* 7 143 1863

10 Charbonnier Perforation de la base du crâne par un coup de baïonnette, *Arch de med et pharm mil* 30 195-199, 1897 Choux, C Contribution à l'étude des plaies pénétrantes du crâne par armes piquantes, *Arch de med et pharm mil* 28 379-395, 1896 Gasset, A Deux observations de blessures produites par la baïonnette Lebel modèle 1886, *ibid* 54 16-24, 1909 Moingeard, A Contribution à l'étude des plaies par épee-baïonnette Lebel, *ibid* 30 396-417, 1897 It is regretted

After the invention of automatic firearms and high explosive heavy missiles, the incidence of incised wounds of all types became even less. Among the 1,046,533 officers and enlisted men in the American Expeditionary Forces of World War I, 224,089 casualties were reported by the Medical Department, with only 235 men admitted to the hospital listed as having bayonet wounds. Of the men admitted to the hospital because of bayonet wounds, 4 died and 9 were discharged because of resulting disability.¹¹ Just what was the incidence of head injuries caused by bayonets is not recorded, but it seems significant that Cushing¹² did not include a single bayonet wound of the head in his reports. The British, similarly, so far as I can determine, did not report any such injuries. However, nearly all the incised wounds of the eyelids, as observed by Würdemann,¹³ had been caused by bayonets, though this author failed to state the number of such injuries. Penetrating ocular wounds were rarely seen by the medical officer, according to Würdemann partly because of the fatal nature of such wounds, for a direct bayonet thrust into the orbit resulted in deep laceration of the brain, with rapidly fatal hemorrhage. Such a casualty would therefore be included in the "killed in action" statistics. These are notoriously inaccurate as bases for accounting for causes of death.

A review of the medical literature of World War I also discloses the rarity of bayonet wounds. Although Morax and Moreau¹⁴ reported one ocular wound caused by a bayonet, Piccoli's¹⁵ report is the only description of a penetrating bayonet wound of the head incurred in World War I that I have found. Piccoli's patient, while engaged in hand to hand fighting in 1916, received a penetrating cranial wound caused by a bayonet which entered the left zygomatic region, causing immediate loss of consciousness. He later rallied and recovered, although hemiplegia on the right with facial anesthesia on the left side persisted,

that the reports of bayonet wounds of the head by Ostrowsky, Althoffer and Lacassagne were not available. These are Ostrowsky, A. M. Penetrating Wounds of the Cranial, Thoracic and Abdominal Cavities, *Voenno-med J* 225 5-27 1909. Althoffer, C. Des plaies par instruments piquants et en particulier par la baïonnette, Lyons, 1890. Lacassagne, A. Des effets de la baïonnette du fusil Lebel, Lyons, 1889.

11 Love, A. G. Medical and Casualty Statistics, in *The Medical Department of the United States Army in the World War*, Washington, D. C., Government Printing Office, 1925, vol 15 pt 2, pp 1019, 1021 and 1022.

12 Cushing, H. A Study of a Series of Wounds Involving the Brain and Its Enveloping Structures, *Brit J Surg* 5 558-684, 1917-1918.

13 Würdemann, H. V. Injuries of the Head and Eyes in Warfare, *Mil Surgeon* 49 443-455 1921.

14 Morax, V., and Moreau, F. Étiologie des blessures oculaires par projectiles de guerre, *Ann d'ocul* 153 321-332, 1916.

15 Piccoli, G. Su di un caso raro di lesione del mesencefalo per ferita d'arma bianca, *Policlinico (sez prat)* 31 153-155, 1924.

probably due to a lesion in the cerebral peduncle and fifth cranial nerve on the left side

Although bayonets continue to be common implements of war and were carried by troops on both sides of the conflict in World War II, they probably were not used so often as is generally thought. In the Pacific Theater, hand to hand bayonet fighting with the Japanese probably occurred more frequently than in any other theater. Of more frequent occurrence was the bayoneting of civilians in the Philippine Islands by Japanese soldiers. To my personal observation, such atrocities were not infrequent on Luzon and Cebu. Nearly all such wounds proved immediately fatal.

I, however, had the opportunity to operate on 4 patients with bayonet wounds of the head. Two of the patients were civilians, and 2 were military personnel. A fifth patient, a Filipino woman, was seen when dying, five days after she had received a penetrating wound from a bayonet in the forehead. In view of the rarity of such reports in the present century, it would seem worth while to report these cases in some detail.

REPORT OF CASES

CASE 1—While in a foxhole at night, a 23 year old American infantryman was attacked by an enemy with a bayonet. The assailant fled on the arrival of another American soldier. By that time the victim had been severely lacerated about the head, face and upper extremities and was unconscious. He was given emergency care at a portable surgical hospital, the facial and cranial lacerations were sutured, and the upper extremities were immobilized in casts. A penetrating cerebral wound could not be debrided, because of lack of facilities and the poor condition of the patient. On the next day he was evacuated to our hospital, but he sustained the trip poorly and required supportive therapy on his arrival. Twelve hours later, with the patient under the influence of block and infiltration anesthesia produced with 1 per cent procaine hydrochloride, the left frontal wound was explored. This wound extended from the inner canthus of the right eye across the root of the nose and left side of the forehead into the left posterior frontal region, about 10 cm above the external auditory meatus. The scalp and the frontal bone were obliquely incised in a somewhat vertical direction. The fractured surface of the frontal bone was actually smooth, giving evidence of having been incised by a sharp instrument. There was minor comminution of the inner table, the bony fragments had been driven into the brain. Linear fractures extended into the right orbit, the medial wall of the left orbit and the left parietal and preauricular regions. The orbital and cribriform plates likewise were fractured on the left, thus allowing forward tilting (elevation) of the left supraorbital section of bone. In the incised fractured area there was sufficient space through which the dural and cerebral wounds could be explored. The dura was found to be lacerated for a distance of 5 cm, through which the bayonet had almost completely amputated about 6 cm of the tip of the left frontal lobe in the antero-lateral aspect (fig 3). A large blood clot and considerable macerated cerebral tissue were aspirated from this area, a procedure which relieved the decidedly increased intracranial pressure. After hemostasis had been obtained, the supra-orbital section of bone was maneuvered back into place and the scalp was closed.

in livers. Since the condition of the patient had not allowed more adequate exposure of the intracranial wound, the dura had to be left unsutured.

The postoperative course of the patient was stormy for five days, necessitating repeated performance of spinal puncture and cisternal puncture for relief of increased intracranial pressure. When these were performed, penicillin in doses of 25,000 to 50,000 units was injected into the subarachnoid and cisternal spaces. Improvement was noted after each subarachnoid drainage. There was no reaction to the penicillin. When the patient was evacuated on the eleventh day, he had been sitting up and walking a little, with assistance, for three days. His mental state was improving. There was no paralysis or aphasia.

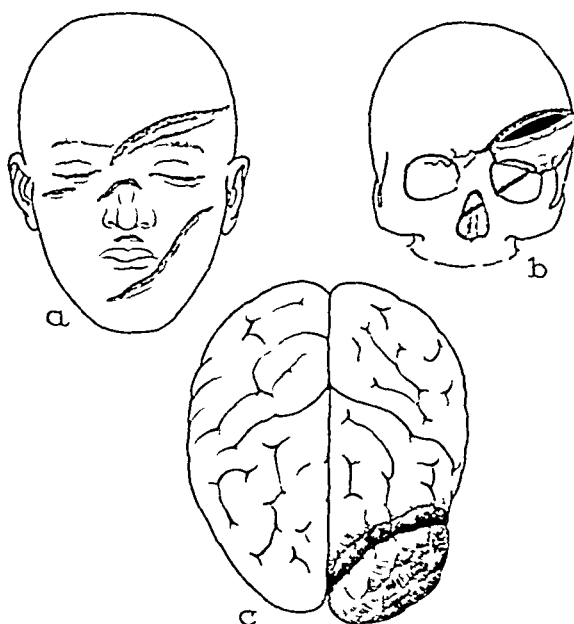


Fig 3—(a) Representation of the multiple bayonet lacerations of the face sustained by the American soldier in case 1, (b) the long, penetrating, incised fracture of the frontal bone incurred by a bayonet, with secondary fractures of the orbital plate, zygoma and temporal bone, (c) lacerated amputation of the tip of the left frontal lobe.

CASE 2—A 22 year old Filipino soldier was brought to the hospital about fourteen hours after he had received a bayonet wound in the right frontal region. He was conscious but somewhat incoherent and overactive. There was a sharply incised wound in the scalp, beginning just within the hair line near the vertex anteriorly, this wound extended somewhat downward and posteriorly to the right, terminating about 4 cm above the pinna of the right ear. The wound was approximately 9 cm long. After routine preoperative therapy, the wound was explored with the patient under the influence of local anesthesia, eighteen hours after injury. Debridement of the scalp and exposure of the skull disclosed a somewhat elliptic fracture of the right frontal bone, about 9 by 4 cm in its greatest extensions. Along the posterior aspect of the wound, where the bayonet had entered, the edges of the fractured bone were typically incised, with only minor

comminution. The posterior border of the fractured elliptic section of bone was depressed about as much as the thickness of the skull. The scalp remained attached to this section of bone. There was slight comminution of the inner table along the posterior margins, with a few small indriven fragments of bone and bits of hair. These fragments of bone and bits of hair were lying in the cerebral wound. Linear fractures extended for short distances from the anterior and posterior extremities of this fracture. There was about 15 cc of blood in the subdural space. The cerebral wound itself was smoothly incised, with minimal maceration of nerve tissue. It was about 5 cm long and 5 cm deep, extending into the corpus callosum in a somewhat V-shaped manner (fig 4). Red softening of the cortex was limited, and petechial hemorrhage was minimal. The brain was moderately swollen, causing some slight tension on the dural sutures when it was closed. Penicillin, to the amount of 25,000 units in each site, was placed

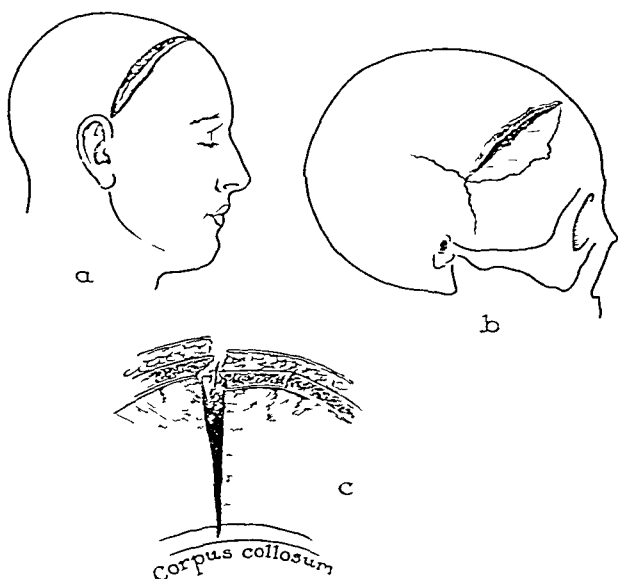


Fig 4—(a) Representation of the penetrating bayonet wound of the head sustained by the Filipino soldier in case 2, showing the scalp laceration, (b) the incised fracture with secondary fracture causing depression of an elliptic section of skull, (c) cerebral lacerations which are shown to extend down to the corpus callosum with concomitant moderate destruction of nerve tissue

both above and below the dura after replacement of the elliptic section of bone that had been elevated to expose the brain.

The wound healed quickly, and the postoperative course of the patient was satisfactory. Results of neurologic examination, made sixteen days after the operation, were entirely normal. A superficial psychiatric survey, however, suggested evidence of damage to the frontal lobe. The patient was evacuated to rear echelons.

CASE 3—A 16 year old Chinese girl was first examined forty-nine hours after she had been bayoneted in the left parietotemporal region. She was conscious, coherent and cooperative, although severely dehydrated. Her temperature was 104.8 F (40.4 C). The neurologic examination disclosed mild paresis of the right

lower side of the face and right upper extremity. Babinski's reflex was present on the right, without demonstrable change in the deep or superficial reflexes. Results of the sensory examination were not entirely satisfactory, and there appeared to be some loss of sensory function in both acuity and localization. The scalp wound was situated in a vertical direction over the postcentral region, extending from the vertex down through the pinna of the ear to a point just anterior and slightly above the external auditory meatus. The depth of the wound was directed forward in a slicing manner and was seen to extend through the skull into the brain. Roentgenograms disclosed a long oval fracture involving the anterior part of the left parietal bone and the anterosuperior portion of the squama of the left temporal bone (fig 5). This oval or elliptic section measured approximately 9 by 4.5 cm in its greatest extension. Its posterior edge was elevated about as much as the thickness of the skull at this point. There was

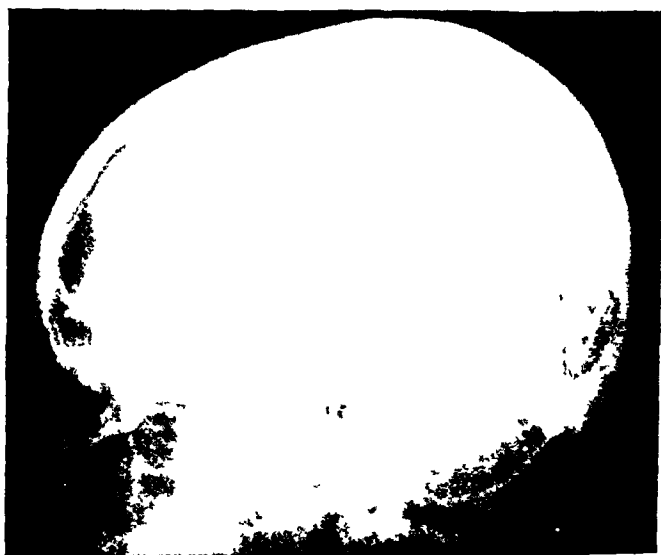


Fig 5—Preoperative roentgenogram of the left lateral aspect of the cranium showing the penetrating bayonet wound sustained by the Chinese girl in case 3. An incised fracture is seen in the left parietal bone, with the lines of fracture extending into the left temporal area.

minor comminution of the inner table of the upper third of this section, with depressed, indriven fragments of bone. In addition to the head wound, there were nine severe lacerations from the bayonet in the left upper extremity.

After this patient had received plasma, whole blood, penicillin and sulfadiazine by vein, her condition improved sufficiently to permit definitive care of her wounds. The operation was performed with the patient under the influence of ether oxygen anesthesia produced intratracheally. First, the scalp was irrigated with solution of penicillin and debrided. Then the incised fracture of the skull was exposed by a short, curvilinear incision extending from the upper angle of the wound. The elevated elliptic section of bone was further elevated and removed because of possible infection in it and in order to obtain better exposure of the cerebral

wound The dura mater was found to be lacerated throughout the extent of the wound There was about 25 cc of blood in the subdural space. The brain was acutely swollen and hyperemic, with minimal red softening and petechiae limited to the edges of the laceration The cerebral laceration was about 3 cm deep It contained a small amount of blood, macerated nerve tissue and a few small fragments of bone (fig 6) No large vessels had been severed, and there was no active bleeding Little intracranial debridement was necessary The dura mater was closed with interrupted black silk sutures, after which 50,000 units of penicillin was injected under the dura into the cerebral wound After the scalp had been closed in layers, another 50,000 units of penicillin was injected beneath it. Postoperative therapy consisted in administration of sulfadiazine, penicillin and plasma and the institution of an adequate fluid and caloric intake Spinal puncture for relief of headache was performed thirty-six hours after the operation, and 25,000 units of penicillin was injected into the spinal subarachnoid space

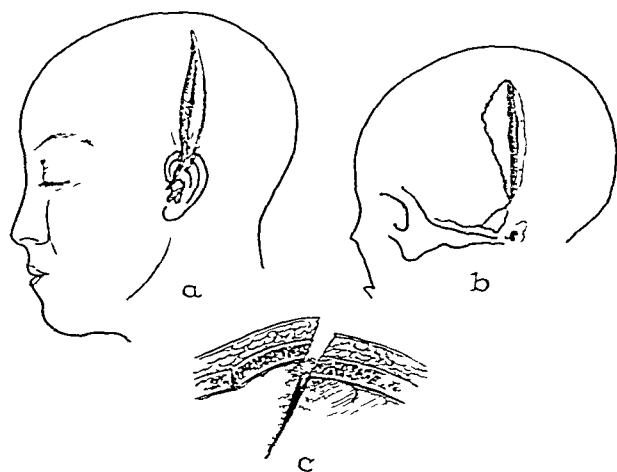


Fig 6—(a) Representation of the bayonet wound of the head in case 3, showing the linear lacerations of the scalp and ear, (b) the incised fracture of the skull, with extending fracture lines and elevated flap of bone, (c) the incised portion of meninges and brain, with minimal damage to the surrounding tissue of the brain.

The patient became conscious four hours after the operation, and when she was examined eighteen hours later she was alert, cooperative and completely oriented The neurologic examination disclosed mild motor hemiparesis on the right side The right upper extremity was affected more than the lower The postoperative course was followed by uninterrupted recovery of the patient. She was ambulatory after the third day The scalp sutures were removed on the fifth day The patient was last examined on the twenty-first postoperative day At that time the wound was well healed, and neurologic examination disclosed only slight facial weakness on the right, with moderate loss of sensory function in the right upper extremity and right half of the head. This was a cortical type of deficit.

CASE 4—A 14 year old Filipino boy arrived at the hospital eighteen hours after he had been struck down by a bayonet wielded by a Japanese. He had a large jagged, incised penetrating wound in the left frontoparietal region, which obviously extended deeply into the brain His condition was poor because of shock and

hemorrhage. Neurologic examination disclosed the patient to be in a semi-conscious state, from which he could be aroused to obey simple commands. There were complete hemiplegia and motor aphasia on the right side, with positive signs of involvement of the pyramidal tract on this side. After routine preoperative therapy, which included the transfusion of 500 cc. of whole blood and the intra-

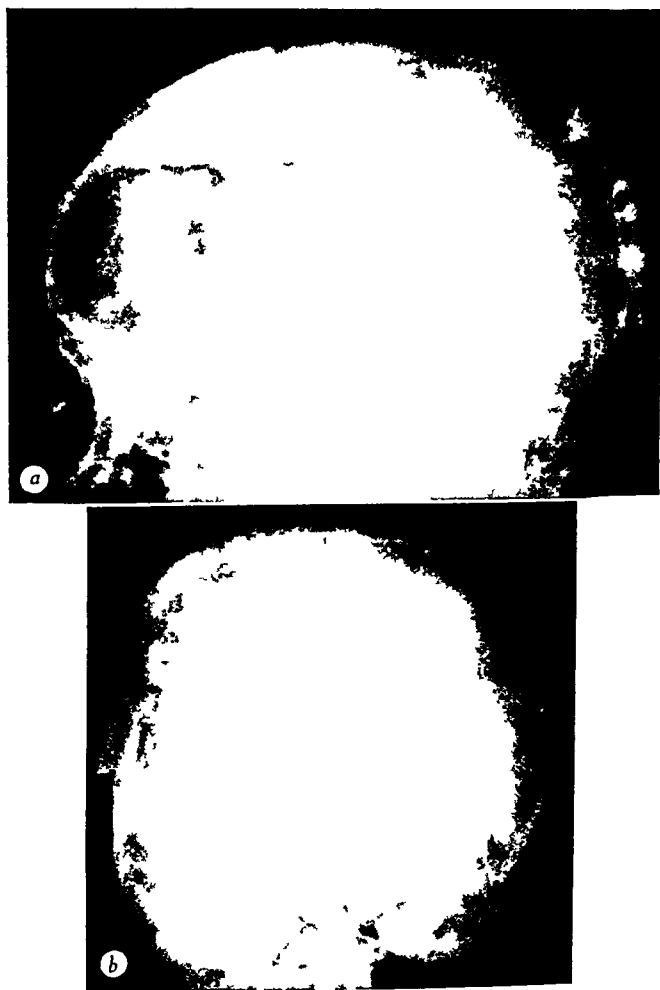


Fig 7—(a) Preoperative roentgenogram of the left lateral aspect of the cranium, showing the extensive compound, comminuted fractures in the left frontal and parietal bones sustained by the Filipino boy in case 4, with depressed indriven fragments of bone, (b) anteroposterior view in the same case. The excessive heat and humidity of the Philippine Islands often made it impossible to obtain better roentgenograms.

venous administration of concentrated plasma, penicillin and sulfadiazine, the condition of the patient improved sufficiently to permit surgical intervention. First, a roentgenogram was made (fig 7). With the patient under the influence

of ether-oxygen anesthesia produced intratracheally, the wound in the scalp was debrided. While the operation was proceeding, it was found necessary to transfuse another 500 cc of whole blood. Next, by extension of the wound by means of anterior and posterior curvilinear incisions, it was possible to reflect the scalp and to expose a large, roughly triangular, traumatic cranial defect measuring approximately 8 by 4 cm. Several large fragments of bone lay on the dura and in the cerebral wound. These were readily removed. Linear fracture lines extended from this area anteriorly across into the right frontal region, posteriorly into the left parietal bone and down into the left occipitotemporal region. The cranial traumatic defect was slightly enlarged with the rongeurs to expose adequately a lacerated portion of the dura mater about 10 cm in length. A depressed section of the left frontal bone was easily elevated, after which the brain was explored. The cerebral wound was directed anteroposteriorly, extending from in front of area 8 (Brodmann) posteriorly into the postcentral region.

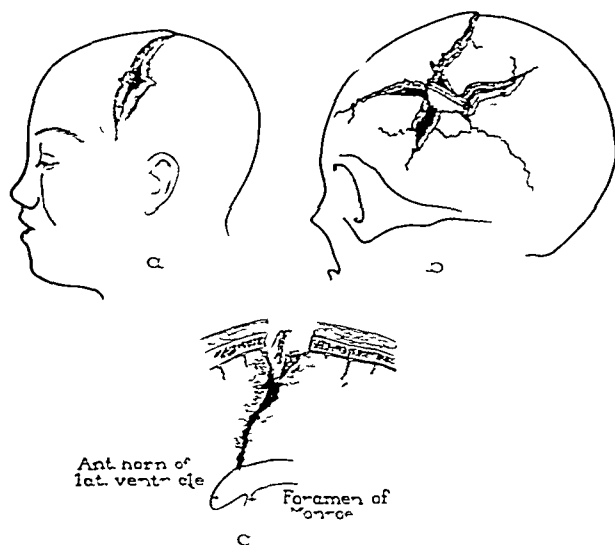


Fig 8—(a) Representation of the penetrating bayonet wound of the head concerned in case 4, showing the irregular laceration of the scalp, (b) extensive fracture of the skull, with indriven fragments of bone, (c) deep incisions and contusions of the brain, extending into the ventricle at the interventricular foramen.

Many vessels had been severed, a few of which were actively bleeding. The cerebral wound was filled with macerated nerve tissue, blood clots and fragments of bone. There was considerable red softening in the surrounding nerve tissue (fig 8). From the appearance of the wound it was obvious that the bayonet had twisted and turned considerably after it had been thrust into the brain. When the depth of the wound was explored, it was found to extend into the anterior horn of the lateral ventricle. The floor of the ventricle was contused as was also the tissue about the interventricular foramen. The cerebral wound was thoroughly debrided. Next, 50,000 units of penicillin sodium dissolved in 5 cc. of isotonic solution of sodium chloride was placed in the ventricle while the pulse rate, respiratory rate, blood pressure and condition of the skin were closely observed. There was no change evident in the condition of the patient. Another 50,000 units of penicillin was injected into the cerebral wound after the

dura had been closed. After this, the scalp was closed in one layer with silk sutures. Two other minor lacerations of the scalp (frontal and parietal) caused by a bayonet were debrided and sutured. By this time the condition of the patient had become extremely poor, however, after 500 cc. of whole blood had been transfused for the third time he rapidly improved, and he was taken to the ward tent in good condition.

The postoperative course for thirty-six hours was turbulent, after which the condition of the patient progressed smoothly. With the assistance of his mother, he was able to walk a few steps on the fourth postoperative day, and he was up and about daily from that time onward. Neurologic examination on the tenth postoperative day disclosed persistence of the hemiplegia on the right side and motor aphasia, a month later these symptoms were still present. Between the tenth and thirtieth postoperative day the patient was cared for in a civilian hospital. At the end of this period he was returned to the Army hospital because of an infection of the scalp wound. This wound subsequently was closed after the infection had been brought under control with penicillin and sulfadiazine.

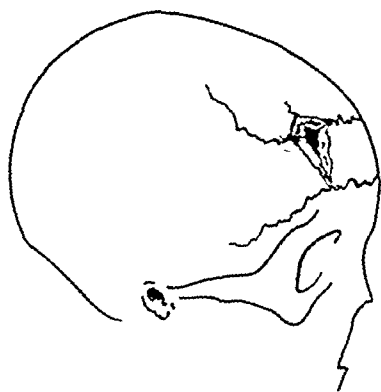


Fig 9—Puncture-fracture of the skull in case 5, caused by a bayonet. The wound was triangular, with linear lines of fracture extending from the angles of the triangular fracture.

CASE 5—A Filipino woman, five months pregnant, was brought to a battalion clearing station because of multiple bayonet wounds that had been inflicted by the Japanese five days previously. Examination disclosed a semicomatose woman who had, in addition to a bayonet wound of the head, some twenty-three puncture and incised wounds of the back and extremities. All the wounds were heavily infected. The wound on the right side of the forehead was situated just below the hair line and measured about 4 cm in its vertical extension. The puncture-fracture of the skull (fig 9) was somewhat triangular, with the base of the triangle situated at the upper end of the wound. The fracture was badly comminuted. On further examination and with the assistance of roentgenograms, linear fractures were seen to extend from the angles of the triangle. Foul-smelling, necrotic and purulent material was herniating through the wound. The patient died a few hours later, while attempts were being made to improve her poor condition by the administration of plasma, penicillin and sulfadiazine and by the transfusion of blood.

COMMENT

The type of head wound produced by a bayonet depends on the type of bayonet used and on the way the bayonet strikes the head of the victim. Ordinarily, this weapon is used with a thrust and hence produces a puncture type of wound. Slicing and tangential blows may have been the method of production of a few of the incised wounds of the scalp reported from the American Civil War. However, sabers and swords are likely to produce long linear wounds with a smooth, incised fracture of the skull. Such wounds may be inflicted by a bayonet, as occurred in the bayonet wound of the patient reported on herein in case 3. Certain wounds, sometimes called "oblique section" with "separation of an osseous flap," were commonly incurred from the saber or sword but are extremely uncommon if not rare from the thrust of a bayonet. Since the bayonet is more or less blunt, the injury is likely to be a badly con-

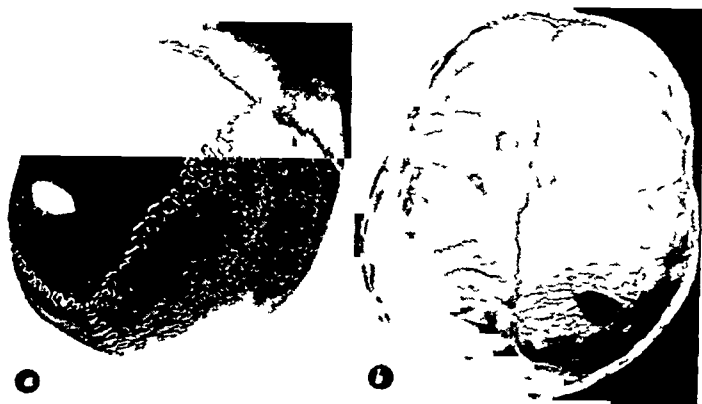


Fig 10—Parietal perforation on the left, consequent to a bayonet wound inflicted during the American Civil War. In *a* the external surface of the calvarium is seen, in *b* the internal surface of the calvarium is shown. The victim died of meningitis and abscess of the brain (specimen 2179, Army Medical Museum, Washington 25, D. C., photographs by courtesy of Colonel James E. Ash, M. C., Director, Army Institute of Pathology.)

tused wound. As pointed out by Bill¹⁶ in 1882, the soft tissues about a bayonet wound usually fall together after the weapon has been withdrawn, leaving a heavily contaminated wound, for the bayonet all too commonly has been used for utilitarian purposes and therefore is nearly always soiled. The bayonet used in the American Civil War was triangular in section, it tended to make roughly triangular puncture-fractures in the cranium, with three extending branches (fig 10). The size of the cranial wounds varied considerably, but in general all were reported

16 Bill, J. H. Sabre and Bayonet Wounds, Arrow Wounds, in Ashhurst, J., Jr. The International Encyclopaedia of Surgery. A Systematic Treatise on the Theory and Practice of Surgery by Authors of Various Nations, New York, William Wood & Company, 1882 vol 2, pp 101-118.

as small Those of the Civil War were variously described "The perforation in the skull barely admitted the point of the index finger," and "about an inch in length and three-fourths of an inch in breadth" ⁸ Small fragments of bone were commonly found depressed or indriven for varying distances into the cerebral tissue In the reported cases the cerebral tissue frequently was found to be severely contused, although simple lacerations (incised) did occur Laceration of the cortex, with little contusion or maceration of tissue, occurred in only 1 of the cases I have reported (case 3) In the others, there was considerable destruction of cerebral tissue, probably produced from three sources the bayonet, fragments of bone and subsequent hemorrhage

To judge from the reported cases, hemorrhage from both the scalp and the intracranial vessels undoubtedly was an etiologic factor in the immediate death of a victim, but for those who survived the immediate complications to be faced were purulent meningitis, encephalitis and abscess of the brain, any of which, of course, was likely to cause death within a few days Acute purulent encephalitis and meningitis were obvious in the death of a Filipino woman in the fifth case reported herein This patient, however, was moribund at the time she was brought to a clearing station for aid

Rarely does one find a report of a perforating bayonet wound of the head However, from the battle of Pultuska, Poland, in 1806, Briot ¹ in 1817 described such a case The bayonet had entered the "right temple two inches above the orbit, inclined backwards and downwards" and traversed the maxillary sinus of the opposite side, where it passed out and projected about 5 inches (12 cm), having penetrated to the hilt A soldier managed to extract the bayonet after a surgeon had failed Although the victim was then left for dead, he later revived and recovered, apparently suffering only the loss of sight in the right eye ¹

Little need be said concerning the surgical care of bayonet wounds of the head, for the same rules of debridement, hemostasis, tight closure of the dura mater and scalp apply to the treatment of this type of wound of the head as to the treatment of any other penetrating wound of the head When patients who have bayonet wounds of the head are brought in early for care and when sulfonamide drugs, penicillin and modern neurosurgical technics are employed, the fatality rate need not be any higher than that accompanying other types of penetrating craniocerebral injuries

17 Briot, P F *Histoire de l'etat et des progres de la chirurgie militaire en France pendant les guerres de la revolution* Ouvrage couronne par la Societe medicale de Paris, Besançon, Gauthier, 1817, pp 111-112 Briot, P F, cited by Hennen, ⁴ pp 230-231 Fardeau *Observation sur une plaie de tete faite par une bayonnette lancee par un boulet, J gen de med de chir et de pharm* 35 287-291, 1809 quoted by Hennen ⁴ pp 230-231

SUMMARY

The histories and operative data concerning 4 patients who had penetrating bayonet wounds of the head have been detailed. The condition of a fifth patient, who died before operative intervention could be carried out, has been mentioned.

The literature concerning the history of the bayonet and its use in warfare has been surveyed briefly. Bayonet wounds of the head are found to be unusual. In the Surgeon General's report of the injuries incurred in the American Civil War, only 5 examples of penetrating bayonet wounds of the head are recorded, and only 1 case is recorded from World War I. The extreme infrequency of occurrence of such injuries is explained by the method of use of the bayonet, that is, a thrust action is employed which makes the abdomen and chest of the victim much more vulnerable to the weapon than the head.

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USE OF SMALL THREADED WIRES IN THE TREATMENT OF FRACTURES

I Fractures of the Lower Extremities

H R McCARROLL, M D
ST LOUIS

THE SUGGESTION of some form of internal fixation as a means of fracture therapy is frequently considered as an indication that the author is a strong proponent of open reduction and internal fixation. Such is not the case in this presentation. Open reduction and skeletal fixation, whether internal or external, should not be performed in any case in which simple closed methods will suffice. The use of small

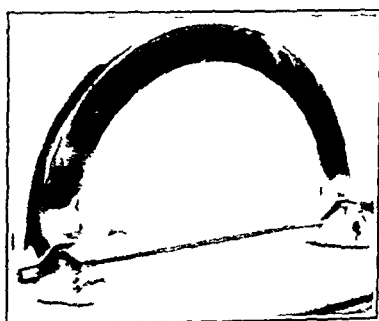


Fig 1—Bow used with the threaded wire for skeletal traction

threaded wires is presented as a simple and safe adjunct to the armamentarium of the surgeon treating fractures for use in instances in which some type of internal fixation is required and for the fractures in which they are applicable. Nothing original is claimed in the basic principles of therapy involved in the types of fractures herein represented. Any procedure requiring a minimum amount of metal for fracture fixation, however, is apropos at this time, since in recent years the medical world has been bombarded with an intensive campaign of advertising for the use of massive pins and some form of external skeletal apparatus.

In the early days of leg lengthening, Crego¹ was instrumental in experimenting with various types of wires which were small in diameter,

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Read before the Section on Orthopedic Surgery at the Ninety-Fifth Annual Session of the American Medical Association, July 4, 1946.

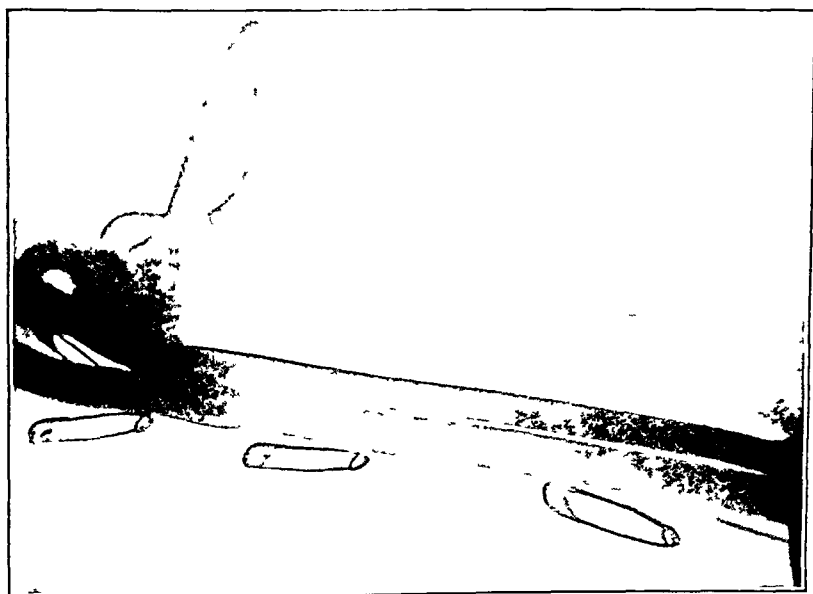


Fig 2 (case E L.)—Fracture of the femur of an 8 year old patient, showing the use of the traction bow and threaded wire in skeletal traction.

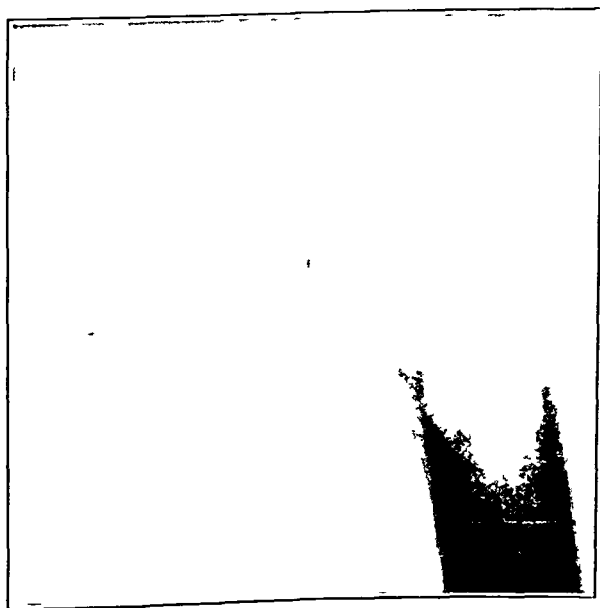


Fig 3 (case A E.)—A badly comminuted intertrochanteric fracture of a patient aged 50. At the time the hip was treated the comminutions were thought too numerous and too small for use of the nail plate or blade plate.

1 Crego, C. H., Jr. The Use of Skeletal Traction as a Preliminary Procedure in the Treatment of Early Congenital Dislocation of the Hip, *J Bone & Joint Surg* 21 353, 1939

yet afforded sufficient tensile strength to withstand the required load. The ordinary velocipede spoke was found to fulfil these requirements and could be easily obtained. By threading the wire throughout its length, tension in the wire could then be obtained by the use of a simple bicycle spoke nipple on each end, the nipples being tightened firmly against the bow of the leg-lengthening apparatus. Since a commercial velocipede spoke is made of plated material, some tissue reaction and discoloration resulted from their use. Wires of 18-8 stainless steel of the same diameter (0.086 inch [0.21 cm]) were then substituted. With these no

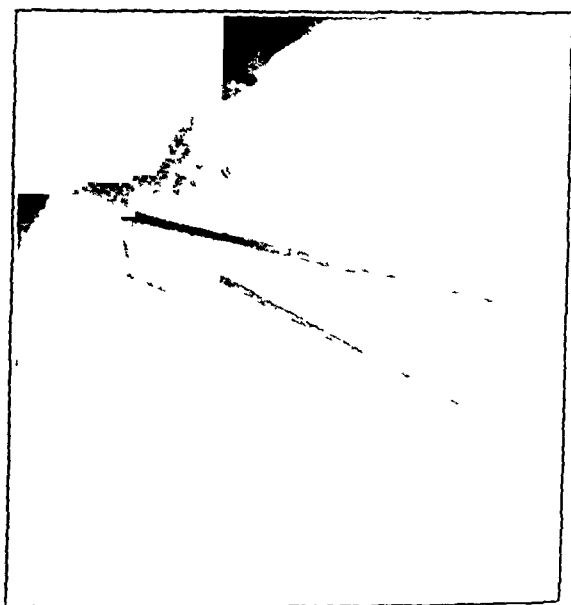


Fig. 4—Result after reduction of the fracture shown in figure 3, showing fixation by means of two threaded wires. Long leg plaster casts and cross bars were used for external fixation. Wires were removed at six weeks.

further tissue reaction occurred, and the leg-lengthening procedure was simplified by their use.

An attempt to apply this same principle in all cases of skeletal traction was an obvious subsequent step. The Kirschner type of wire and traction bow has always seemed objectionable—first, because the bow rested across the front of the leg below the knee and thus made it impossible to place the knee in complete extension when desired and, second, because there was invariably a tendency for lateral play of the wire through the extremity, and this resulted in some infections. By use of wires which were threaded throughout their entire length, it was soon found that the tendency to lateral shifting of the wire was corrected and

the incidence of infection was almost entirely abolished. Wires of this type and the bows from the leg-lengthening apparatus were used for ordinary skeletal traction in many cases. This bow was unsatisfactory, however, because the wire had to be drilled through the bow, and this often interfered with correct placement of the wire. After further trial and error, in which bows of many different patterns and material were used, a type (fig 1) was found which could be slotted and added after

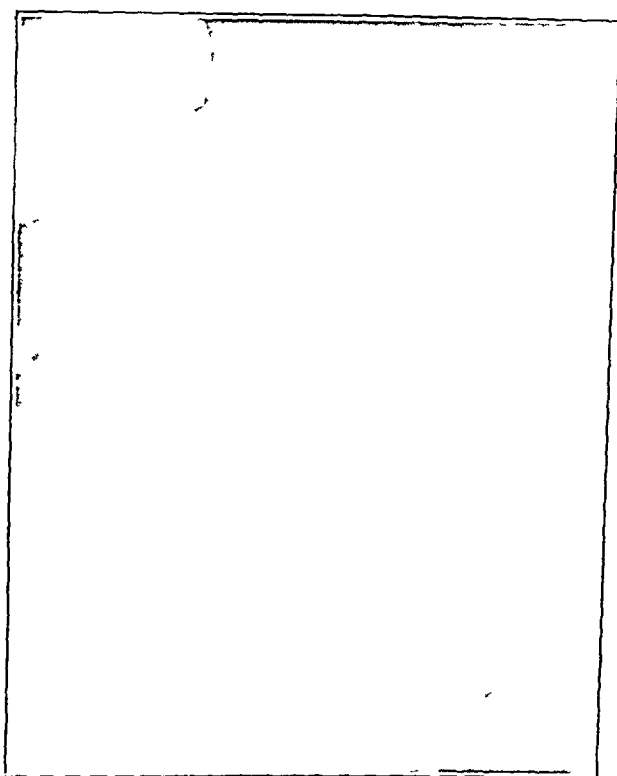


Fig 5—Satisfactory alignment and bony union ten weeks after operation (figs 3 and 4). A blade plate or nail plate is now being used in this type of fracture.

the wire was inserted and still maintain sufficient strength to withstand the pressure to which it was subjected. This type of bow and wire has now been used over a period of ten years for skeletal traction in several hundred cases (fig 2) and has been proved satisfactory in every respect. A $3/32$ inch (0.24 cm) wire has also been used, because it can be more easily machine threaded without twisting and breaking. Small nuts are available commercially to fit both wires and take the place of the bicycle spoke nipple.



Fig 6 (case O C) —Spiral fracture of the tibia and fibula in a patient aged 56



Fig 7—Fracture shown in figure 6 after attempted closed reduction and fixation in a plaster cast

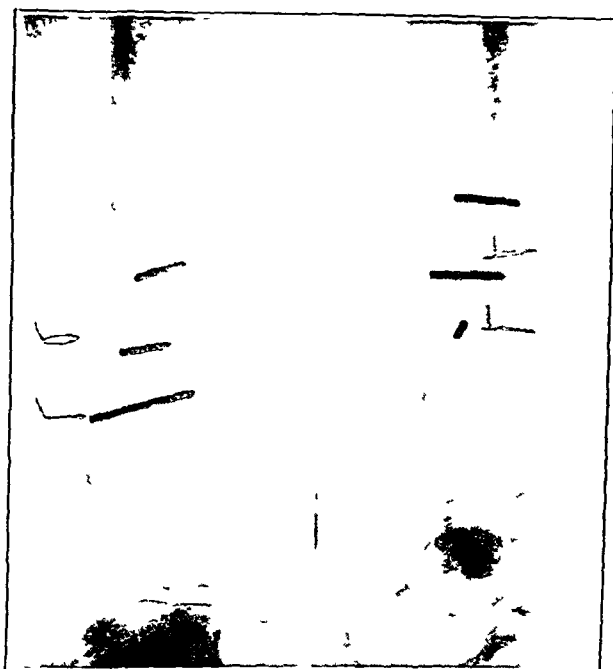


Fig 8—Fracture shown in figures 6 and 7 after open reduction and fixation of the tibia with three threaded wires and of the fibula with two small flexible wires

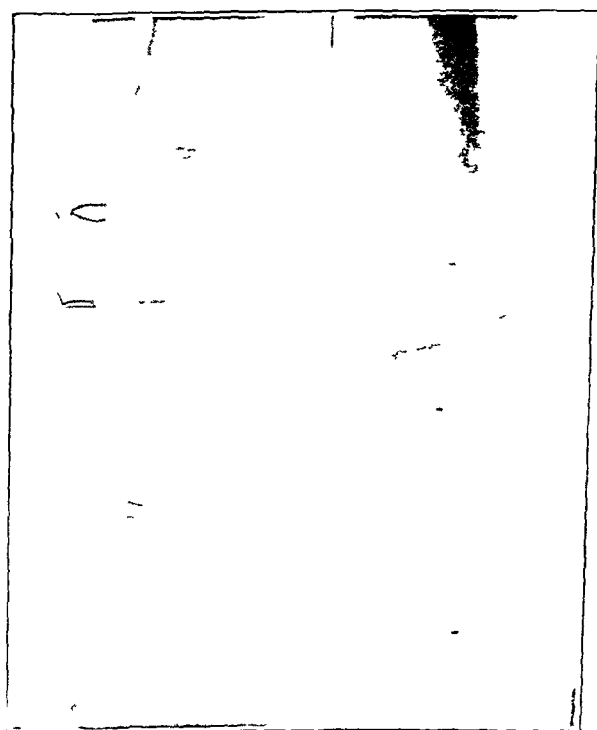


Fig 9—Appearance of fracture (figs 6 7 and 8) after fourteen months. Plaster fixation was used for four months. Solid bony union was acquired. The result was good. The wires were not removed.

In my estimation the qualities and advantages of the threaded wire made it superior to other types. It was about this time that Miller² reported the use of Kirschner wires in the fixation of bone grafts. If the threaded wire was superior to the smooth wire for skeletal traction, it would seem equally superior for the fixation of bone grafts or for the internal fixation of other fractures. It was tried therefore, first exactly as Miller recommended. From this beginning, their application has spread to include many types of fractures. The wires may be allowed

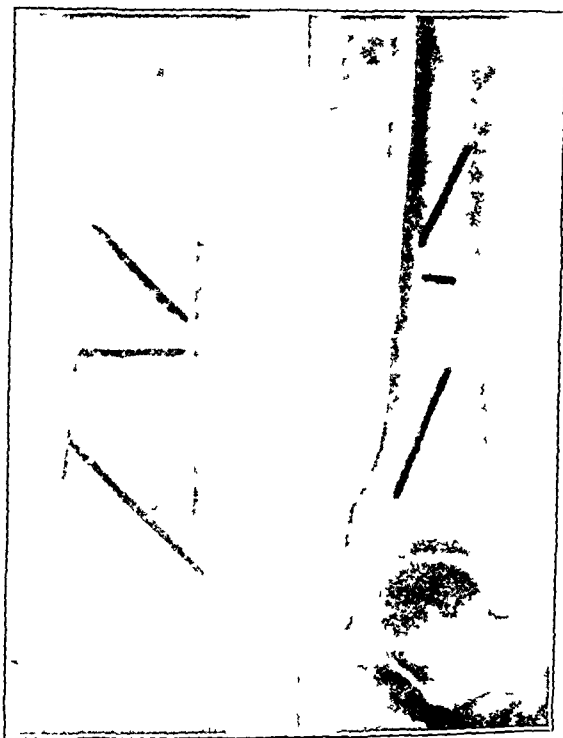


Fig 10 (case G B) —Spiral fracture of the tibia with a transverse fracture of the fibula in a patient aged 47. The original roentgenogram was lost. Displacement was similar to that in figure 6. Fixation was done with three threaded wires. A plaster cast was used for three months.

to protrude for later removal or may be cut off flush with the surface of the bone and used in the same way that screws are used. With the threaded wire, no tendency for the wire to "wander" has been encountered.

² Miller, O. L. Simplified Internal Fixation of Inlay and Onlay Bone Grafts, *J. A. M. A.* 113:635 (Aug. 19) 1939.

When the threaded wire is placed through the extremity for skeletal traction or when used in metaphyseal regions of bone (cancellous) for fixation of fracture fragments, no preliminary drilling of the bone is needed. When the wire is used for fixation of heavy cortical bone, however, as in transfixing of the fragments of spiral or oblique fractures of long bones, it has been found that preliminary drilling of the wire tract is an essential step. Before this was learned an attempt was made to force the pointed threaded wire through these fragments of heavy cortical bone with a motor drill. It was found impossible to control the speed of the wire to make the rate of introduction correspond exactly to the

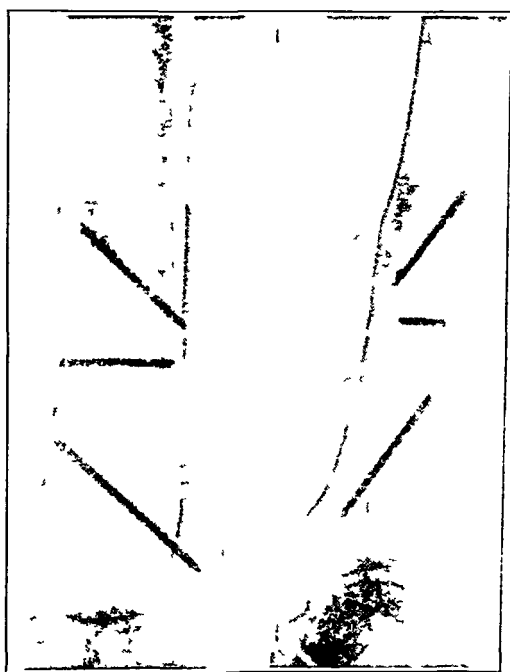


Fig 11—Solid bony union and maintenance of normal alignment three years later in case G B (fig 10). The result was good. The wires were not removed. There was a slight area of rarefaction at the tip of two of the wires.

number of threads per inch (25 cm) on the wire. (There are fifty-six threads to the inch, which would have meant only fifty-six revolutions for each inch of passage for the wire. With dense bone and a motor drill, this was an impossibility.) The wire in these instances reamed out a hole of equal diameter through the bone and did not cut threads in the bone. The result was inadequate fixation and loss of position of the fracture fragments in some instances.

In cortical bone, preliminary drilling with an 0.070 inch drill point (no. 50 of the standard drill point gage) for use of the 3/32 inch

threaded wire and a 0.067 inch drill point for the 0.086 inch wire insure solid fixation. This fixation has proved to be as secure as that obtained with screws. The optimum length so often a problem in the selection



Fig. 12 (case E. B.)—Comparative roentgenogram showing the result in a bimalleolar fracture one year after closed reduction in a patient aged 30 years. Note the nonunion in the medial malleolus and the inferior displacement in the lateral view (arrow). Compare this with figures 15 and 19.



Fig. 13 (case L. C.)—Fracture of the medial malleolus in a patient aged 30 years after manipulation showing inability to approximate the anterior lip of the fracture in the lateral view.

of screws is of no consideration when threaded wires are used. The wire is simply drilled in the required distance and cut off when desired. With preliminary drilling of this type, the hand drill is preferable and

is always used both for the drilling and for the insertion of the wire and pointing of the wire is not necessary. When used without preliminary drilling pointing of the wire is essential.

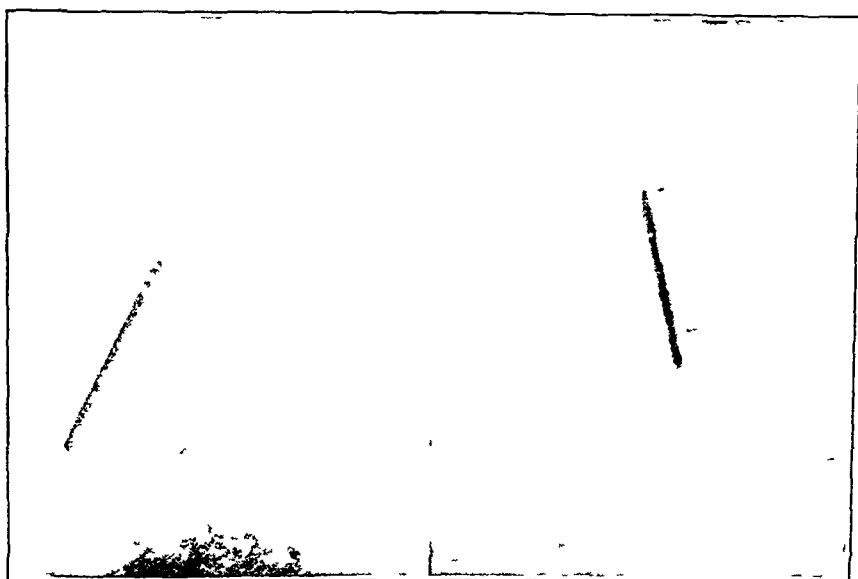


Fig 14—Fracture shown in figure 13 immediately after open reduction and internal fixation with one threaded wire



Fig 15—Appearance in case L C (figs 13 and 14) three months later, showing a normal ankle joint. The wire was not removed.

In the lower extremity, certain fractures at times require open reduction and internal fixation. In many of these small threaded wires

have been used, and in certain types of fractures they have been found superior to other means of internal fixation. Fractures of the lower

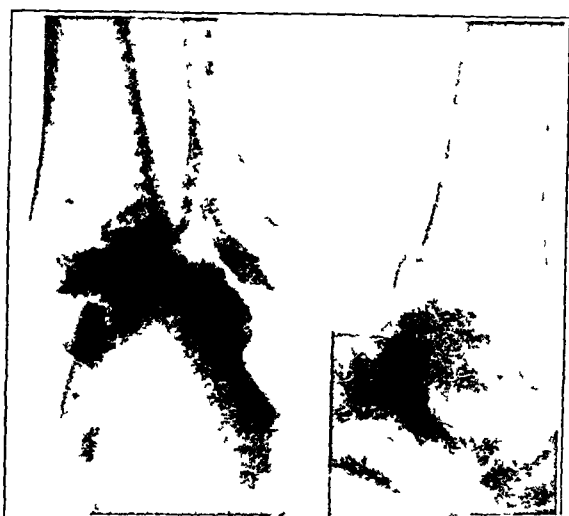


Fig 16 (case D G)—Comminuted trimalleolar fracture with posterolateral displacement in a patient aged 27



Fig 17—Unsatisfactory apposition after attempted closed reduction of the fracture in figure 16

extremity in which this means of internal fixation has been tried are as follows

1 It has been used for comminuted intertrochanteric fractures of the femur Prior to the widespread use of the nail plate or blade plate



Fig 18—Roentgenogram in case D G (figs 16 and 17) immediately after open reduction of both malleoli, showing the threaded wire for the medial malleolus protruding through the skin for later removal Flexible wire was used for the fibula.



Fig 19—Roentgenogram in case D G (figs 16 17 and 18), showing appearance of the ankle eight months later The threaded wire was removed at four weeks A plaster cast was used for four weeks and a walking plaster for four weeks Total fixation was done in eight weeks

for fixation of these fractures, many attempts were made to obtain some improved means of fixation for these fractures and decrease the

long period of immobilization. With this in mind, the threaded wires were used in several instances. The fracture in 1 such case is shown in figures 3, 4 and 5. After excellent nail plates and blade plates

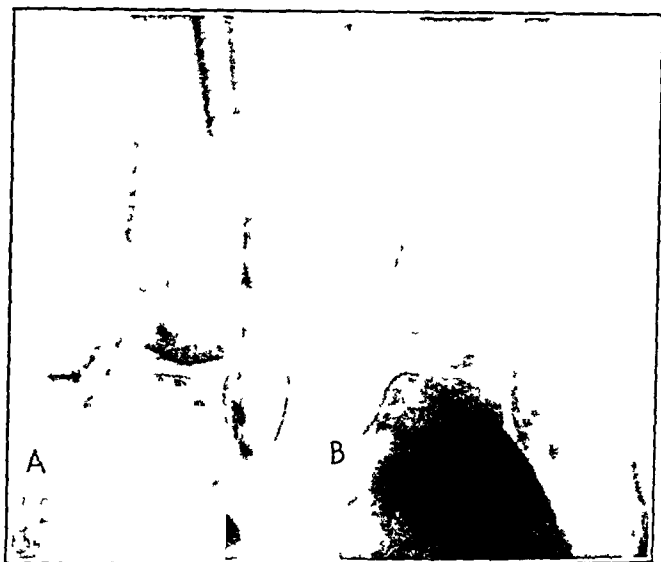


Fig 20 (case D G) —A, bimalleolar fracture in a patient aged 38 years after initial manipulation by a local physician. This was an eversion fracture with lateral displacement in the beginning. B, unsatisfactory apposition of the medial malleolus after the second manipulation.



Fig 21—The fracture in case D G (fig 20) immediately after open reduction and fixation of the medial malleolus only with two crossed threaded wires.

became available they were found to afford better fixation and the use of threaded wires for this type of fracture was discontinued.

2 It has been utilized for spiral or oblique fractures of the long bones. For fractures of the tibia and fibula, threaded wires afford excellent

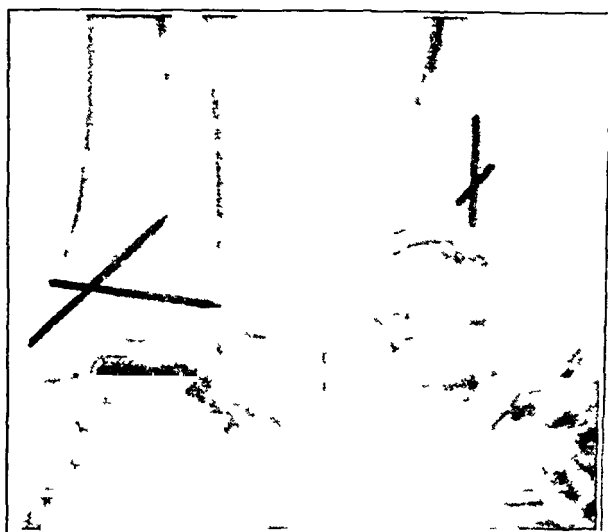


Fig. 22—Satisfactory union and satisfactory joint contour in case D G (figs 20 and 21) eight weeks after operation. The wires were not removed.

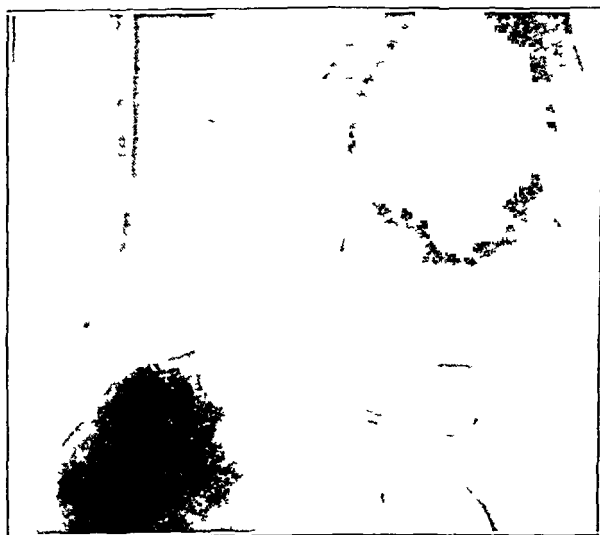


Fig. 23 (case H M)—Comminuted fracture of the distal end of the fibula, partial lateral dislocation of the ankle and complete dislocation of the astragalo-scaphoid joint in a patient aged 44 years.

fixation (figs 6 to 11). It must be stressed again, however, that preliminary drilling with a drill point or smaller diameter is essential

If an attempt is made to force the wire through heavy cortical bone with a power drill, a hole of equal diameter will be reamed out and inadequate fixation will result



Fig 24—Fracture shown in figure 23 after open reduction through one lateral incision and fixation of the fibular fragments with one threaded wire. The wire was not removed



Fig 25—Appearance of the fracture in case H M (figs 23 and 24) after eleven months. The result was good. Motion of the ankle joint is excellent.

These wires have also been used for similar fractures of the femur and have proved entirely unsatisfactory. They will not withstand the

torce and strain to which they are subjected in a fracture of the shaft of the femur. For this fracture, simple skeletal traction is far superior and is preferable, as has been pointed out by many authors previously.

3 It has been used for fractures about the ankle joint, that is, those of the medial malleolus, bimalleolar or trimalleolar with displacement (figs 13 to 25). This probably represents the most valuable usage for the small threaded wire. Unless perfect approximation of these fragments can be obtained by closed reduction, traumatic arthritis of the ankle follows and a poor result is obtained. Nonunion of one or more fragments is not uncommon (fig 12). The majority of fractures of this type should have open reduction, accurate replacement of fragments and internal fixation. At operation, the medial malleolus is invariably found to be separated from the shaft of the tibia by an interposed flap of periosteum and fascia which has been stripped away from the surface of the bone at the time of injury and has dropped between the fragments with their separation. Removal of this interposed soft tissue is an absolute prerequisite to anatomic replacement and reduction. Small fragments of articular cartilage are also occasionally found lying loose in the ankle joint and should be removed. Screws are too large for fixation of these small fragments and often result in their comminution. The smooth Kirschner wire does not hold as well. The threaded wire combines the desirable features of the two and is by far the most ideal.

SUMMARY

A short general discussion on the use of small threaded wires together with their use in treatment of fractures of the lower extremities is presented with roentgenographic reproductions of the procedure in representative cases. The small size of the wire, the excellent fixation afforded by the threads and the minimum amount of trauma to bone and soft tissues insured by their use render them superior to other forms of internal fixation in certain types of these fractures.

USE OF SMALL THREADED WIRES IN THE TREATMENT OF FRACTURES

II Fractures of the Upper Extremities

H R McCARROLL, M D

ST LOUIS

IN A PREVIOUS presentation¹ a general discussion of the development and use of the small threaded wire in the treatment of fractures was given. A repetition of that discussion does not seem necessary at this time. Although these wires were used originally in the lower extremities their use was soon attempted in various fractures of the upper extremities, and here too they were found to be ideal in certain types. The fractures in which open reduction and internal fixation are sometimes necessary or preferable and in which the use of the small threaded wire has proved satisfactory are as follows:

1 They are used for fractures of the clavicle. In children a fracture of the clavicle seldom if ever requires open reduction. In adults, too, open reduction is seldom indicated, but an occasional case is encountered in which adequate approximation as seen in anteroposterior and oblique views is impossible. In such instances nonunion may follow. Murray² in 1940 described intramedullary fixation of such fractures by means of the Kirschner wire. Intramedullary fixation with a threaded wire has been used (fig 1), the wire being drilled through the cortex, cut off flush with the surface of the bone and left in permanently. The fixation afforded by the threads prevents any tendency for the wire to wander. A sling is used for comfort and further protection for four to six weeks.

2 They are utilized for dislocation of the acromioclavicular joint. Unless adequate replacement of the clavicle and firm fixation are insured, a permanently relaxed acromioclavicular joint may result. Open reduction is easily attained through a small overlying incision, and one or two threaded wires can be drilled through the acromion and into the clavicle under direct vision (figs 2, 3 and 4). The wires are allowed

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1 McCarroll, H. R. Use of Small Threaded Wires in the Treatment of Fractures. I. Fractures of the Lower Extremities, Arch Surg, this issue, p. 138.

2 Murray, G. Method of Fixation for Fracture of Clavicle. J. Bone & Joint Surg. 22: 616, 1940.

to protrude for later removal. The torn capsule of the joint and overlying ligaments are then easily resutured. A Valpeau type of support is used for four weeks and a sling for four additional weeks. The wires are usually removed at six weeks.

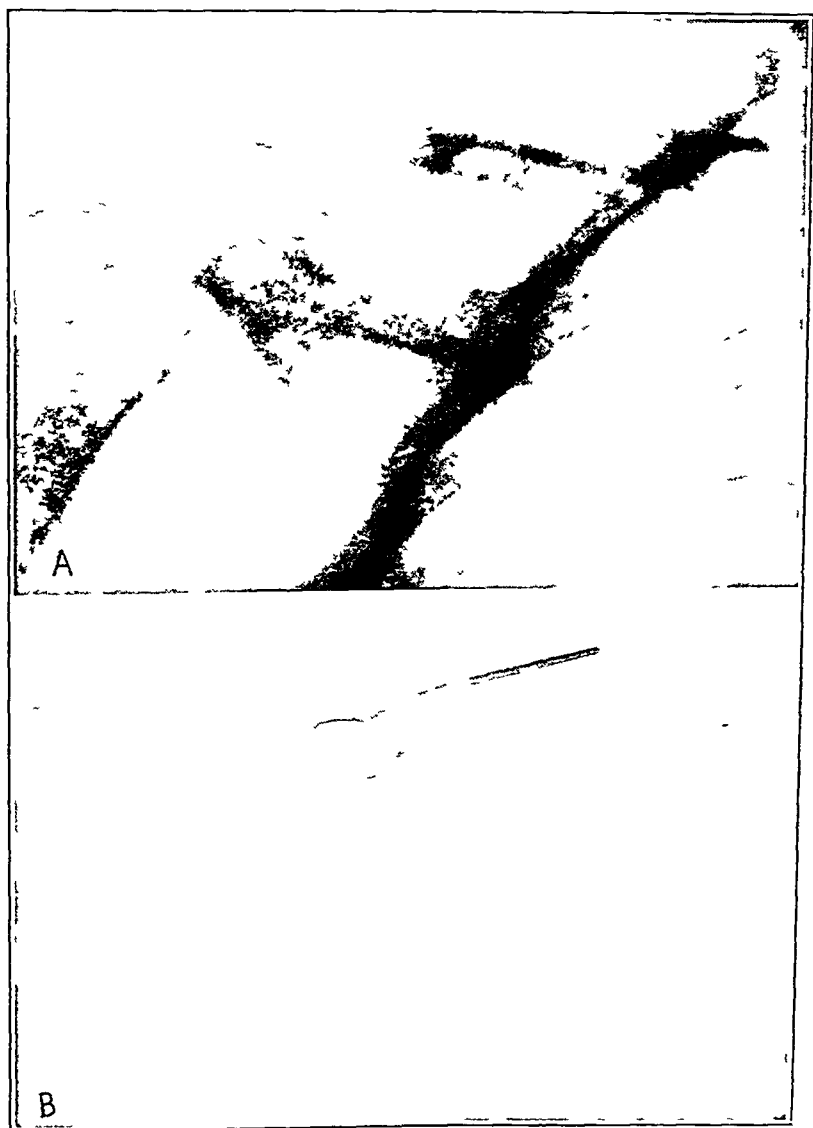


Fig. 1 (case L. M.)—A fracture of the clavicle in a patient aged 55 years after application of figure of 8 bandage. The oblique view shows definite separation of fragments the reason for open reduction. B position and union ten weeks after open reduction and intramedullary threaded wire fixation. A flexible wire loop was also employed. The result was good.

3 They are used for fractures of the proximal end of the humerus. This may include a fracture of the tuberosity with displacement (fig 5). This fragment may remain abducted or rotated by the pull of the



Fig 2 (case F S) —Complete acromioclavicular separation in a patient aged 36 years

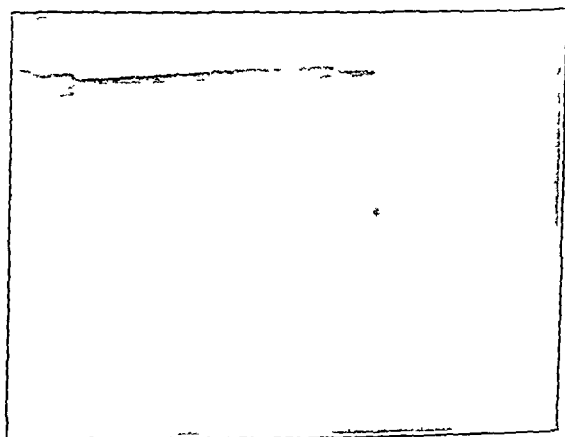


Fig 3—The fracture in case F S (fig 2) after open reduction and fixation by means of two threaded wires which were allowed to protrude externally.

supraspinatus tendon after attempted closed reduction or after reduction of the dislocation of the shoulder, which usually accompanies this type of fracture. In this event open reduction and adequate fixation by

means of threaded wires have proved superior to other forms of fixation. The wires are usually allowed to protrude for removal after five to six weeks. A sling is used for external support for six weeks, but exercise of the shoulder is begun extremely early.

Fractures of the surgical or anatomic neck of the humerus often become badly displaced and offer a problem, since adequate reduction is impossible unless the resulting rotation of the humeral head can be corrected. As a rule, open reduction is necessary in order to accomplish this. This is done through a small anterior incision, and adequate approximation of the two fractures is easily brought about. Reduction

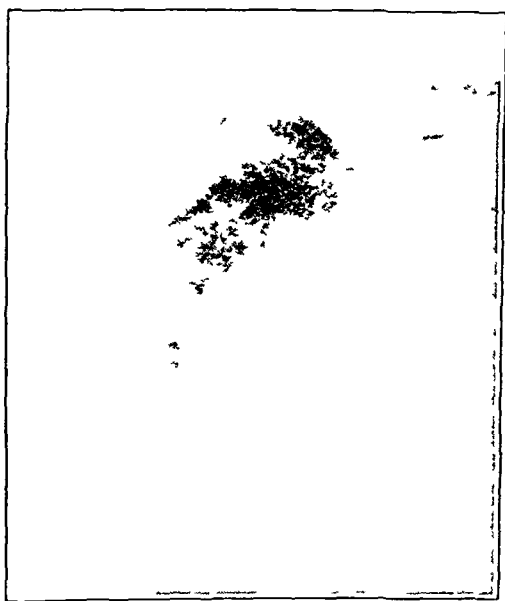


Fig 4—Appearance in case F S (figs 2 and 3) four months later. Wires were removed at six weeks. The result was good.

and proper alignment are easily maintained by the use of two threaded wires drilled through the tuberosity and into the medullary canal of the distal fragment (figs 6, 7 and 8). These wires are always allowed to project for later removal because of possible interference with function of the joint. In figure 6 B the wires appear to cross the articular cartilage. This, however, is not done, as the wires pass through the tuberosity lateral and anterior to the articular margin. If there is any fear of the wire's wandering farther into the medullary canal, this can be easily prevented by the application of a nut to the projecting portion of the threaded wire (fig 8 B). A hanging cast is used for six weeks, and a sling is used for two additional weeks. The projecting

wires are removed at four weeks. Pendulum exercises for the shoulder are begun during the first week.

† They are used for fractures of the epicondyle of the humerus with displacement. These fractures usually require open reduction. The fragment is easily held firmly in place with a towel clip, and a small threaded wire drilled through the fragment and into the humerus affords



Fig 5 (case D D) — *A*, fracture dislocation of the shoulder in a patient aged 38. Fluoroscopic examination after closed reduction shows the tuberosity rotated and laterally displaced. *B*, appearance two weeks after open reduction and threaded wire fixation of the tuberosity. The wires were allowed to protrude. *C*, satisfactory bony union at five weeks, when the wires were removed. The anatomic result was good. The functional result was poor, with the reason unknown.

excellent fixation. This wire is cut off flush with the surface of the epicondyle and is not removed. Plaster fixation of the extremity is also necessary for six to eight weeks.

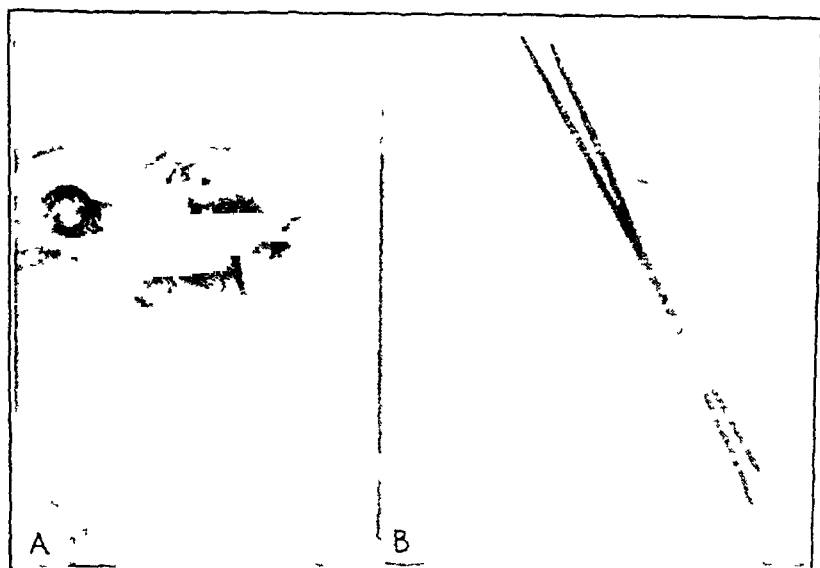


Fig 6 (case K G)—*A* fracture of the neck of the humerus, with striking displacement and with the head of the humerus rotated 90 degrees in a patient aged 65. *B*, after open reduction and threaded wire fixation. A hanging cast was used as external fixation.

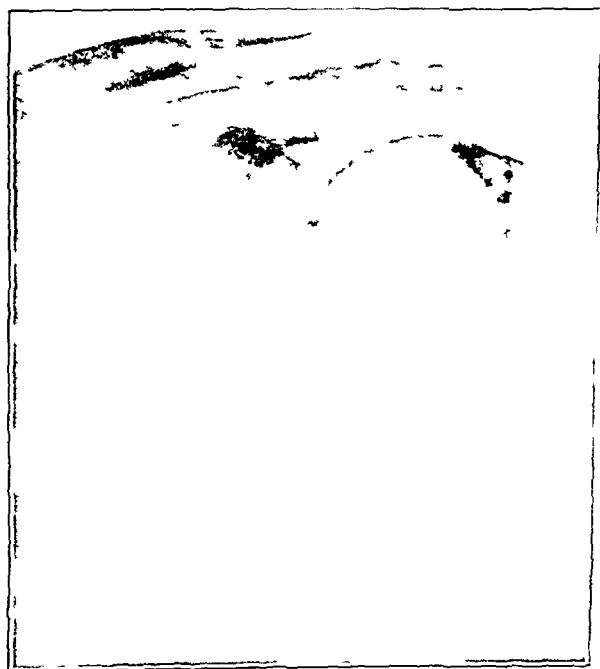


Fig 7—Appearance in case K G (fig 6) at five months showing complete union. The result was good. The wires were removed at four weeks.

5 They are utilized for comminuted fractures of the lower end of the humerus with extreme displacement of the fragments. Closed reduction should always be attempted in these instances, and frequently satisfactory or excellent realignment of the fragments is possible. If

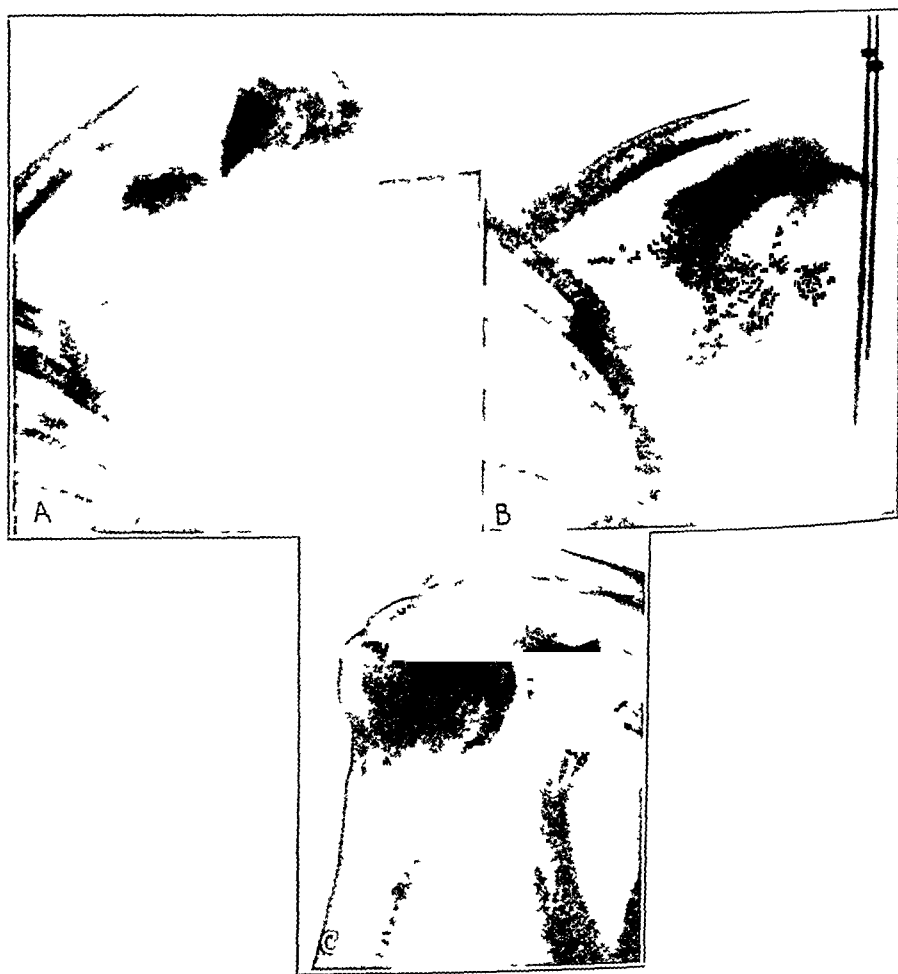


Fig 8 (case D W) —*A* complete epiphyseal separation of ten days' duration in a patient aged 13. *B* after open reduction and fixation with two threaded wires, which were removed at four weeks. A sling was used for external support. *C*, result after eight months. Normal function resulted, but the epiphyseal line is closed. This may result in slight shortening, but it should be insignificant in child of this age.

satisfactory alinement is not obtained, open reduction, adequate replacement of the fragments and internal fixation are advisable. The small threaded wires have proved an excellent means of fixation. The cancell-

lous nature of the bone in this region makes their insertion with a hand drill simple and easy once apposition of the fragments has been obtained. In some instances the wires are used as screws and left

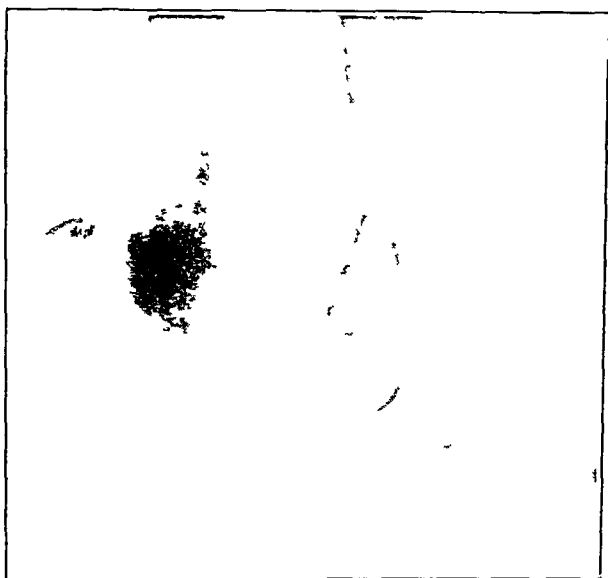


Fig 9 (case V H) —Anteroposterior and lateral views, showing a comminuted supracondylar fracture in a patient aged 44 years

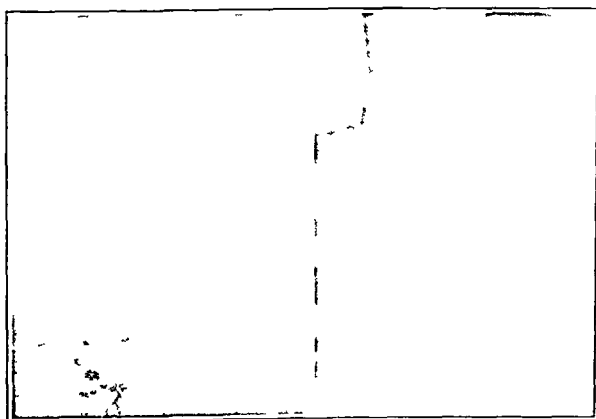


Fig 10 —Unsatisfactory position in case V H (fig 9) after attempted closed reduction

in permanently, while in others they are allowed to protrude somewhat beyond the surface of the bone and later removed. In addition to use in the fractures shown (figs 9 to 16), the threaded wire has been placed

transversely at times to transfix the condyles, the trochlea and the capitellum in one piece where all were comminuted and displaced in the fracture. This reconstructed fragment of the distal end of the humerus is then anchored to the adjacent portion of the shaft by means



Fig 11—Appearance in case V H (figs 9 and 10) after open reduction and threaded wire fixation

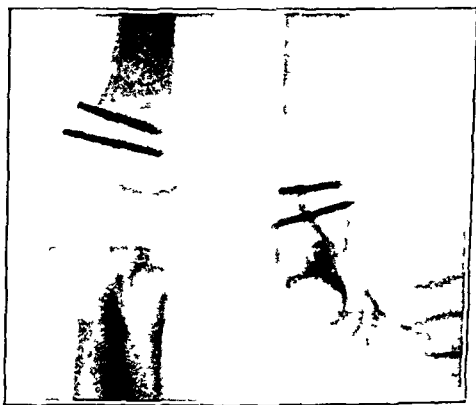


Fig 12—Appearance in case V H (figs 9, 10 and 11) after one year. The functional result was fair with motion through 60 degrees

of a second wire inserted obliquely. Fixation by means of plaster cast is always used for sufficient time to permit union.

6 They are used for fractures of the olecranon. If such fractures are displaced, open reduction is indicated. In this way, the contour of the articular surface can be restored and the interposed periosteal flap so frequently stripped from the cortex at the time of the fracture can be

removed thus facilitating accurate reduction and apposition of the fragments. This is done through a small overlying incision, the fragments are reduced and realigned exactly as in a jigsaw puzzle and are held firmly in place with a towel clip. A threaded wire is then drilled through the fragment and into the shaft of the ulna (figs 17, 18 and 19)



Fig 13 (case P. G.)—Badly comminuted supracondylar fracture of the elbow in a patient aged 47 years



Fig 14—Appearance in case P. G. (fig 13) after attempted closed reduction. The medial epicondyle and trochlea are still displaced

The wire is cut off flush with the tip of the olecranon and is not removed. A long arm plaster cast with the elbow flexed 40 to 45 degrees is used for six weeks. This fracture ranks with the fracture of the malleoli as the most desirable for threaded wire fixation. The use of the wire loop insures neither accurate apposition of the fragments nor restitution of a

normal articular surface. A screw is too large and may result in comminution of the small fragment of the olecranon. The smooth Kirsch-

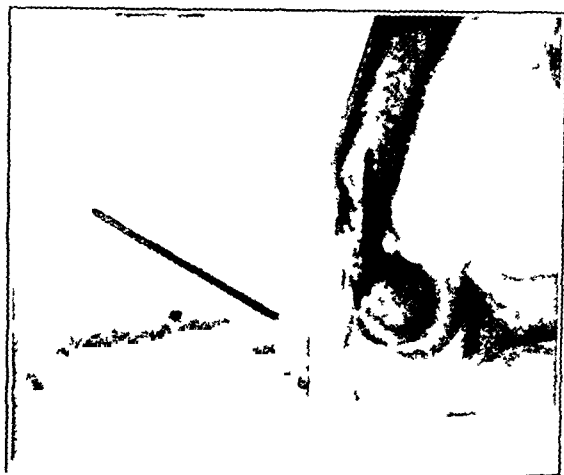


Fig 15—Appearance in case P G (figs 13 and 14) after open reduction, realignment and fixation with one threaded wire. The wire is protruding some for later removal.



Fig 16—Appearance in case P G (figs 13, 14 and 15) after twenty one months. The anatomic result is good. The functional result is fair, with motion of 75 degrees.

ner wire may not hold the fragments under tension. The threaded wire combines the desirable features of all and has proved more satisfactory.

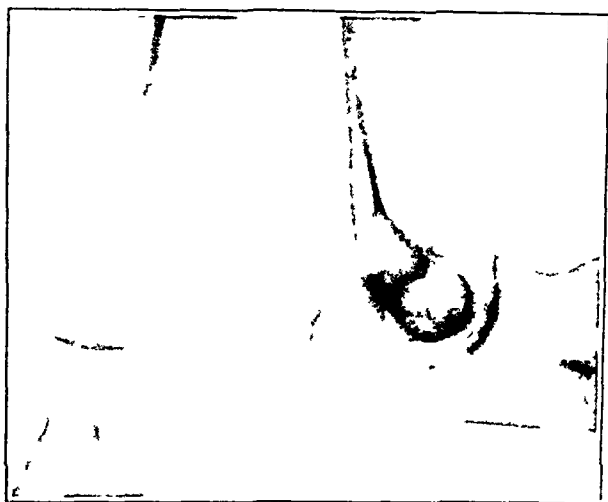


Fig 17 (case M E)—Anteroposterior and lateral views, showing a comminuted fracture of the olecranon in a patient aged 70 years

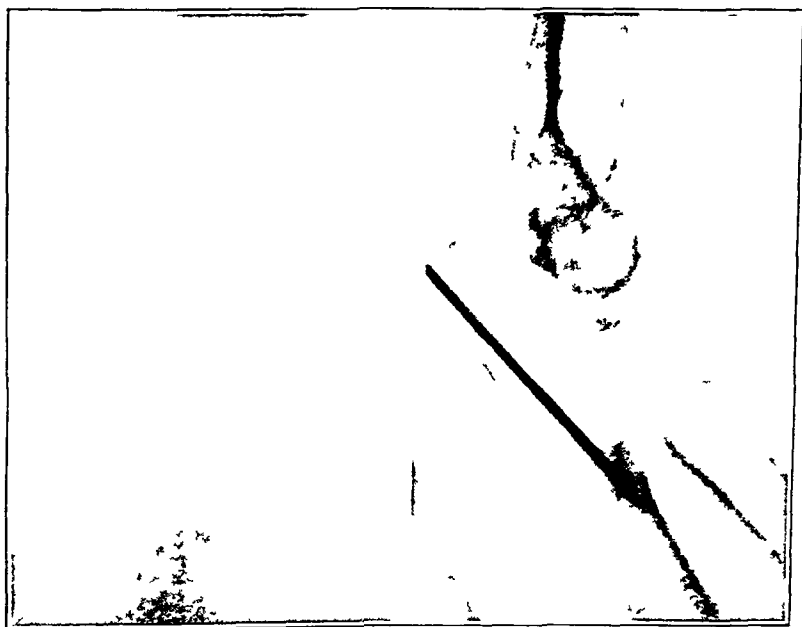


Fig 18—Appearance in case M E (fig 17) after open reduction threaded wire fixation and application of a plaster cast



Fig 19—Satisfactory union and alignment in case M E (figs 17 and 18) after four years. The result is good.

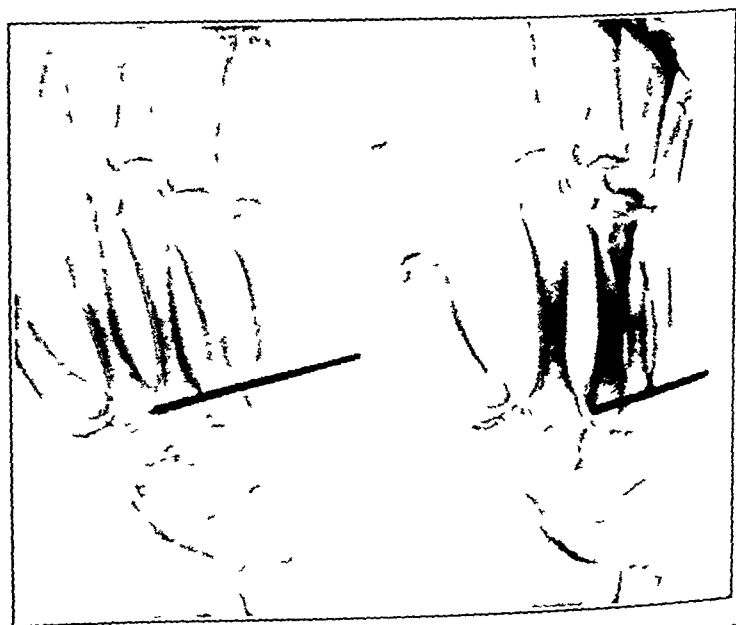


Fig 20 (case H S)—Anteroposterior and oblique views of a fracture in a patient aged 19, showing threaded wire fixation for dorsal dislocation of the proximal end of the fourth and fifth metacarpals.

7 They are utilized for fractures and dislocations of the metacarpal. The threaded wire has been used successfully in these fractures. For dorsal dislocation of the proximal end of the metacarpals, fixation by the

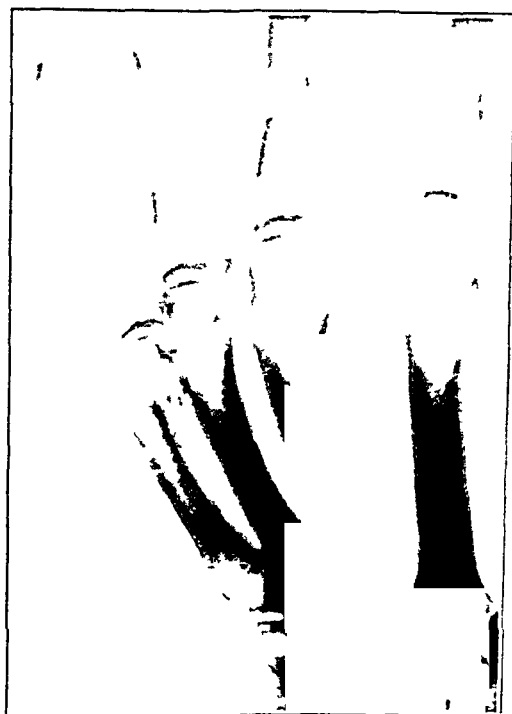


Fig 21 (case W G)—Lateral view of a fracture of the neck of the fifth metacarpal of four weeks duration in a patient aged 35. The result was cosmetically and functionally poor.



Fig 22—Appearance in case W G (fig 21) after open reduction through a short lateral incision and fixation with a threaded wire drilled through the margin of the articular cartilage and into the medullary cavity. No external fixation was used.

threaded wire or some similar means is by far the most satisfactory. In order to save space as few reproductions as possible are used. Only a postreductive view of a dislocation of this type is shown (fig 20). A second case of fracture through the neck of a metacarpal with angulation of metacarpal head to the flexor surface is shown (figs 21, 22 and 23). In a fracture of this type the wire is passed through the distal fragment and into the medullary canal of the metacarpal, after accurate open reduction, through a small incision placed along one margin of the metacarpal involved. The wire is inserted through the distal fragment at the margin of the articular cartilage in order to disturb the structure of the joint as little as possible. In fractures of this nature the wire is always allowed to protrude, and it is removed at four weeks. No

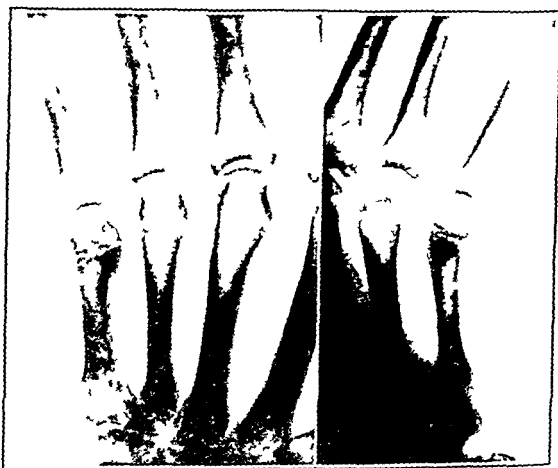


Fig 23—Appearance in case W G (figs 21 and 22) at six weeks. The wire was removed at four weeks. The result was good both functionally and cosmetically.

external fixation is needed, and this permits early institution of active and passive exercise in these hands, an all-important factor in preserving function.

A short discussion of the application of the threaded wire for internal fixation of certain fractures of the upper extremity is presented together with roentgenographic reproductions of treatment and results in representative cases. This is not to be considered as a plea for open reduction and internal fixation. Neither is it to be considered as a panacea for all fracture fixation. But in certain selected fractures in which open reduction is essential for the best end result, the threaded wire affords the most desirable means of fixation. The value of the threaded wire is enhanced by the minimum amount of trauma to bone and soft tissue.

resulting from their use, the minimum amount of metal introduced as a foreign material and the excellent fixation afforded by the threads

• Nothing original is claimed or implied in the principles of fracture therapy demonstrated herein. The idea that wire fixation could be widely utilized for certain fractures arose from the report of Miller³ in 1939. The wire itself was developed by Crego,⁴ who, after years of application in skeletal traction and leg lengthening, first reported its use in 1939.

3 Miller, O. L. Simplified Internal Fixation of Intra and Onlay Bone Grunts, *J. A. M. A.* **113** 635 (Aug. 19) 1939.

4 Crego, C. H. Jr. The Use of Skeletal Traction as a Preliminary Procedure in the Treatment of Early Congenital Dislocation of the Hip, *J. Bone & Joint Surg.* **21** 353 1939.

USE OF SMALL THREADED WIRES IN THE TREATMENT OF FRACTURES

III Their Use in the Fixation of Bone Grafts

H R McCARROLL, M D
ST LOUIS

THE TWO preceding parts of this presentation¹ have dealt with the use of the small threaded wire in fractures of the upper and lower extremities respectively. As stated in part I, it was used first by Crego² in the leg-lengthening procedure and was then used in ordinary skeletal traction. Miller³ in 1939 reported the fixation of bone grafts by means of Kirschner wires. Since the threaded wire had proved superior to the smooth wire in skeletal traction, it was an obvious assumption that it would also afford better fixation for bone grafts.

The first such application of the threaded wire was carried out exactly as recommended by Miller (figs 1, 2 and 3), the wires being allowed to protrude for subsequent removal. The projection of a wire through the surface of the skin, however, entails some risk of infection. Too, it was soon learned that with proper application the wires held so firmly there was no need for removal and they could be cut off flush with the surface of the bone and used in exactly the same way that screws are employed.

In the earlier cases no preliminary drilling for the wire was employed. The pointed wire was forced through the cortical bone with a power drill, and, since the speed of the drill was greater than the rate of introduction for the wire, a hole of equal diameter was reamed through the bone and threads were not cut. In the wire there are fifty-six threads per inch (2.5 cm), and the introduction of the wire 1 full inch to each fifty-six revolutions of the wire by means of the power

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Read before the Section on Orthopedic Surgery at the Ninety-Fifth Annual Session of the American Medical Association, San Francisco, July 4, 1946.

1. McCarroll, H. R. Use of Small Threaded Wires in the Treatment of Fractures. I. Fractures of the Lower Extremities, *Arch Surg*, this issue, p. 148.
II. Fractures of the Upper Extremities, *ibid*, this issue, p. 154.

2. Crego, C. H., Jr. The Use of Skeletal Traction as a Preliminary Procedure in the Treatment of Early Congenital Dislocation of the Hip, *J Bone & Joint Surg* 21: 353, 1939.

3. Miller, O. L. Simplified Internal Fixation of Inlay and Onlay Bone Grafts, *J A M A* 113: 635 (Aug. 19) 1939.

drill was an impossibility. In this way no threads were cut and the wire in some instances would be loose in the wire canal. Before this fact was learned the loss of position of fracture fragments occurred in some instances (fig 16). For the 0.086 inch (0.21 cm) threaded wire preliminary drilling with an 0.067 inch drill point is now used. For the 3/32 inch (0.24 cm) wire, an 0.070 inch drill point is employed. The hand drill is used both for the drilling and for the

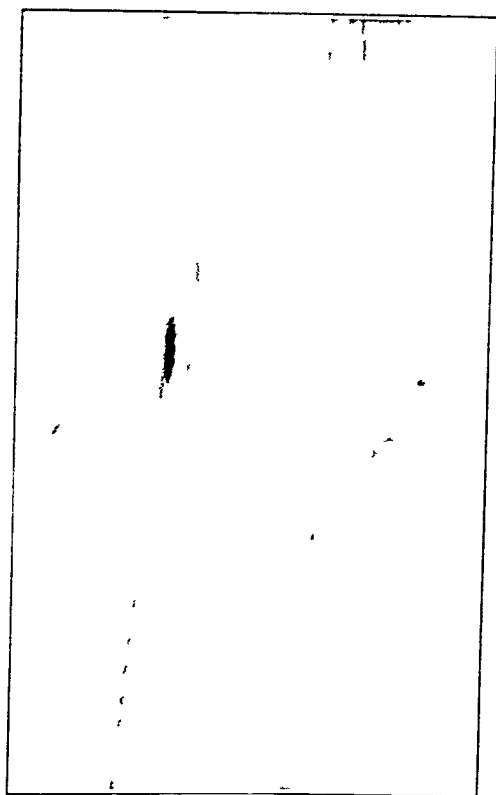


Fig 1 (case R. P.) —Ununited fracture of the tibia of two years' duration in a patient aged 14

insertion of the wire. In this way the wires take hold firmly and no tendency for them to slip has been encountered. When preliminary drilling is used, the wire need not be pointed.

The wire used in this way has afforded fixation which is as firm as that obtained from standard screws. The only advantages the wire has over screw fixation is the small amount of metal required and the lack of worry about obtaining the exact length of screw required. In this method the wire is merely drilled in the desired amount and

cut off at the surface of the bone or graft. This is not a plea that the threaded wire entirely replace screw fixation in anchorage of bone grafts. In the shaft of the femur, for instance, the stress and strain placed on the site of fracture is so great that the threaded wire should not be tried. For all other long bones, however, the fixation afforded has proved entirely satisfactory. The threaded wire, in fact, in my opinion, insures fixation equal to that of the standard metal screw.

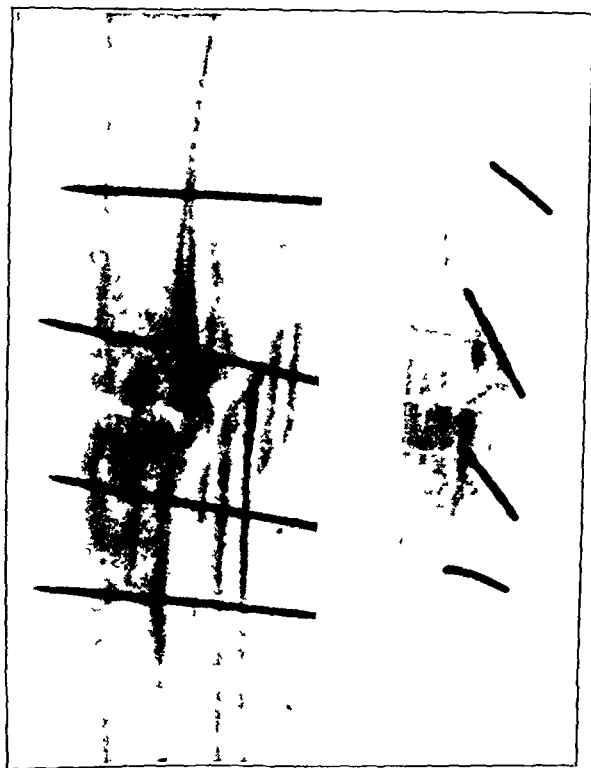


Figure 2

Fig 2—Appearance in case R. P. (fig 1) while the leg was still encased in a plaster cast. A large onlay bone graft was anchored with four threaded wires which were allowed to protrude and which were removed at ten weeks (Miller³). An intramedullary peg was also used.

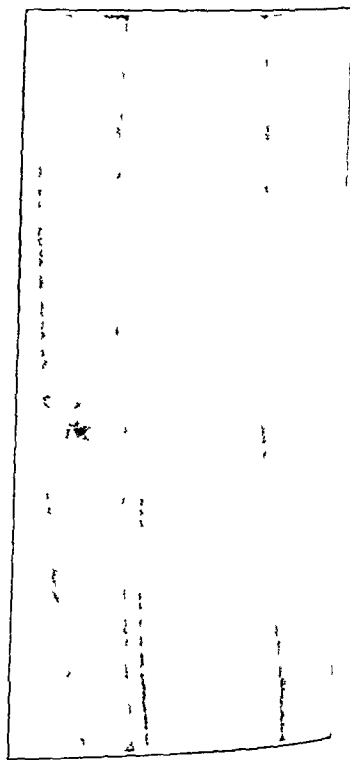


Figure 3

Fig 3—Appearance in case R. P. (figs 1 and 2) two years after operation.

Roentgenographic reproductions of treatment and results in representative cases show the means of fixation by the wires (figs 4 to 17). The operative technic is identical with that of any other bone graft procedure and need not be repeated here.

SUMMARY

In part III of this presentation the application of the small threaded wire for fixation of bone grafts is discussed. The small size of the wire, the excellent fixation afforded by the threads and the minimum amount of trauma to bone and soft tissues insured by their use render them superior to other forms of internal fixation in certain types of these fractures.

ABSTRACT OF DISCUSSION

DR. DOUGLAS E. KING, San Francisco: Most surgeons have had the experience of seeing a Kirschner or Matthews wire wander away from its original location

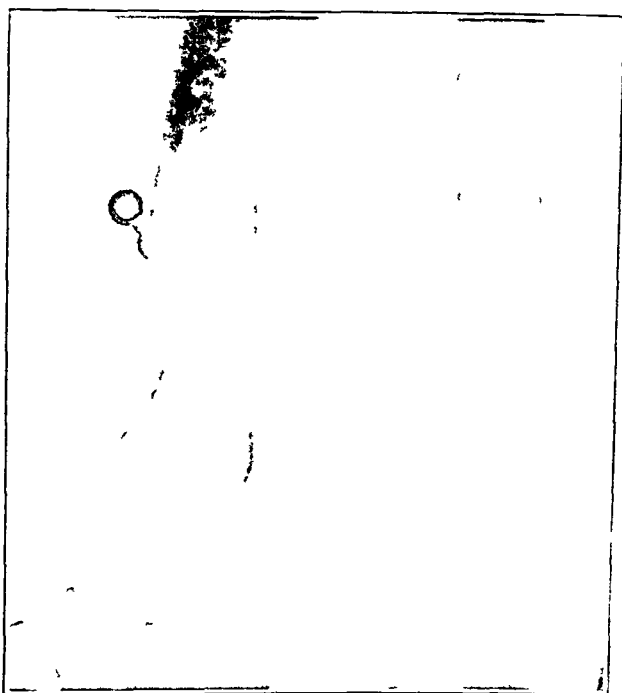


Fig. 4 (case F G) —Ununited fracture of the radius two months after inadequate plating in a patient aged 68 years

into a new and dangerous position. Some years ago I removed one of these wires from the space of Retzius in a patient who had had multiple wire fixation for a fractured hip. Most of these cases are never reported in the literature.

Readers of the *Journal of Bone and Joint Surgery* will recall that in 1941 Bob Mazet reported 2 cases which were excellent illustrations. One was a case of acromioclavicular dislocation in which stiff, smooth-surfaced wires had been inserted, and the second was a case of arthrodesis of the shoulder in which stiff wires had been inserted to hold the humeral head against the glenoid. In each of the patients a wire had migrated into the chest, causing pulmonary difficulties and necessitating thoracotomy. If by using threaded wire such complications can be prevented, then it must be obvious that Dr. McCarroll's idea is a good one.

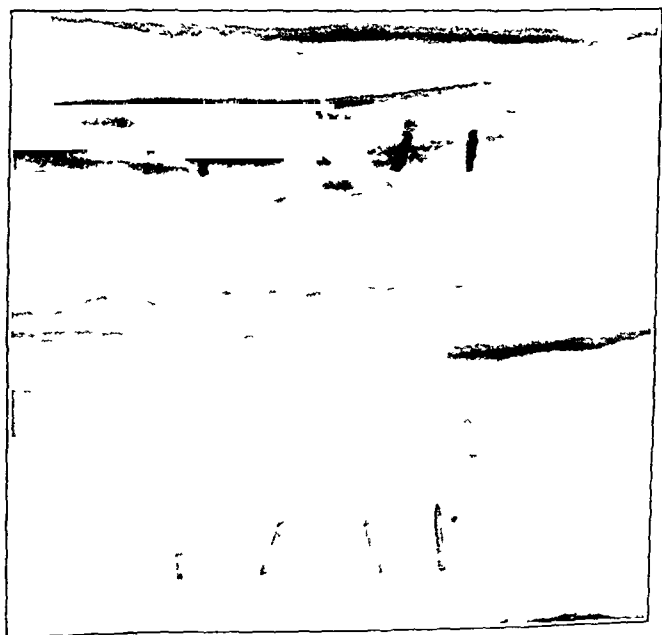


Figure 5

Fig. 5—Appearance in case T. G. from the closed wires.

Fig. 6—Satisfactory result in case T. C. distal subluxation of the distal end of the ulna.

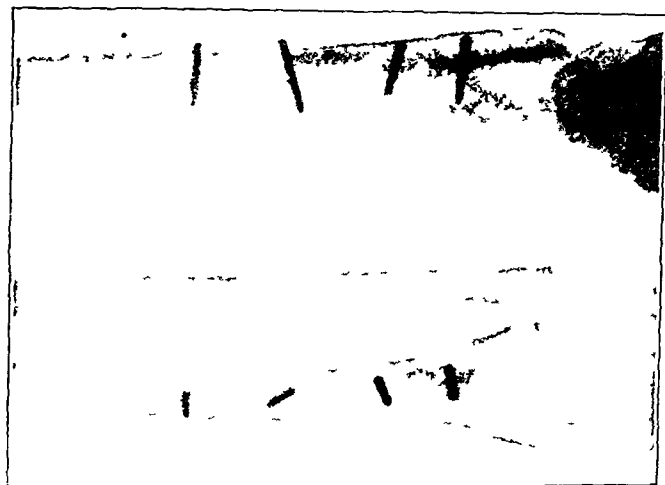


Figure 6

Fig. 6—Application of an onlay graft fixed with bony union six months later. Note the slight

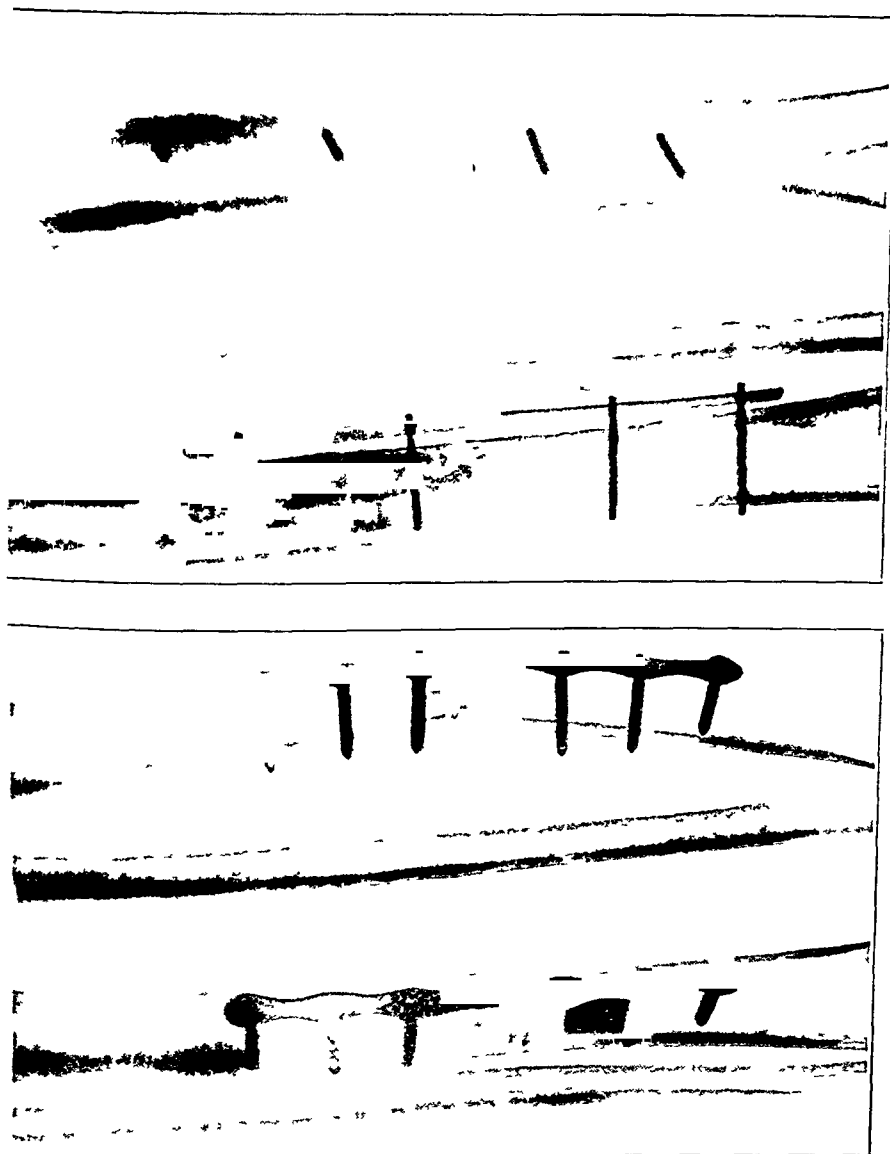


Figure 7

Fig 7 (case J M).—Nonunion of an oblique fracture of the tibia six months after open reduction and application of bone plate in a patient aged 18 years.

Fig 8—Appearance in case J M (fig. 7) with the leg in a plaster cast after removal of the plate and application of a massive onlay graft anchored with four thickened wires. An intra-medullary peg, and three barrel stave grafts (Steele P B Barrel Stave Grafts, in Lectures on Reconstruction Surgery, Academy of Orthopedic Surgeons Ann Arbor, Edwards Bros Inc 1944) were also used. Note the osteotomy of the tibia.

Figure 8

In holding a massive cortical graft I should think that screws would be much better, because the flare of the head presents a large pressure surface against the outer surface of the graft

For a number of years I have used the smooth wire for certain fractures of the elbow joint, such as the capitellar fracture in children and the olecranon process. From now on I am going to use the threaded wire

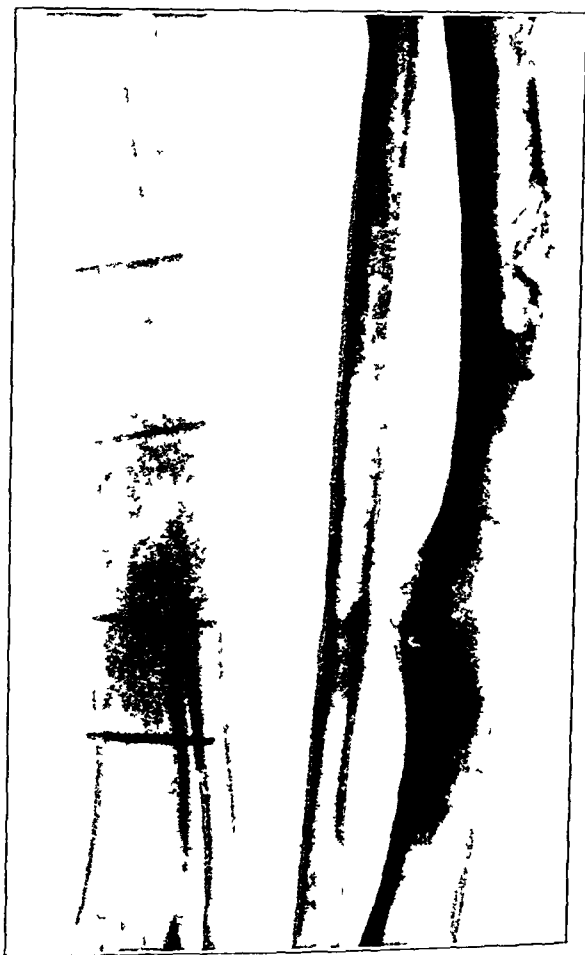


Fig 9—Appearance in case J M (figs 7 and 8) after seventeen months. Fibrous union resulted only with a pseudarthrosis. Nevertheless the threaded wires have not changed in position, and there is no reaction around them. Multiple drilling of the pseudarthrosis has since been done.

Dr McCarroll has pointed out that many fractures of the ankle joint require more accurate reduction and fixation and that the use of the threaded wire is the best method in this anatomic location.

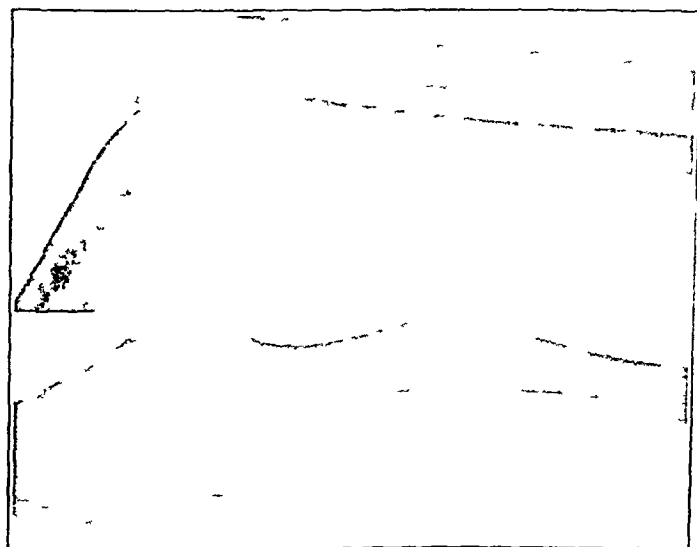


Figure 10

Fig. 10 (case B R) — Ununited fracture of the ulna of one year's duration in a patient aged 19 years



Figure 11

Fig. 11 — Roentgenogram in case B R (fig 10) immediately after application of an only bone graft fixed with four threaded wires

One sentence from the opening paragraph of his paper bears repetition. Open reduction and skeletal fixation whether internal or external should not be performed in any case in which simple closed methods will suffice.

DR FRANCIS M. McKEEVER, Los Angeles. I should like to ask Dr McCarroll whether he has any experience with the use of the threaded wire in the

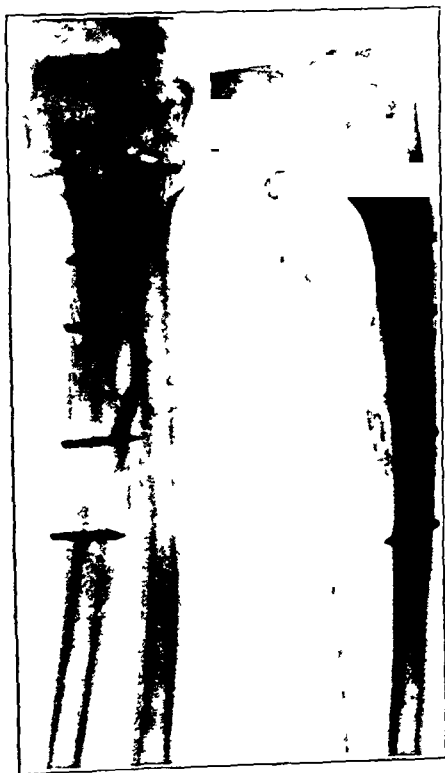


Figure 12



Figure 13

Fig 12—Appearance in case B. R. (figs 10 and 11) after ten months. Solid bony union was established. The result was good with normal function.

Fig 13 (case H. B.)—Ununited fracture of the tibia of six months duration in a patient aged 21 years. He was previously treated by open reduction and external fixation apparatus. Note the absorption at the end of each fragment.

treatment of fractures of the metacarpus and if so whether he has threaded the wire through the articular surface of the metacarpal phalangeal joints. Has it resulted in any stiffness of the joints?

I noticed in one or two of his slides that the wires had been placed through the articular capsule or so it looked to me.

I have nothing but commendation for Dr. McCarroll's paper and I hope to have the opportunity to try the threaded wire. I have had no actual experience with them.

Dr. McCarroll has enumerated all the places that the threaded wire can be used with immobilized fractures and has given visual proof of the effective immobilization afforded by this small wire. Any one who has used screws has



Figure 14

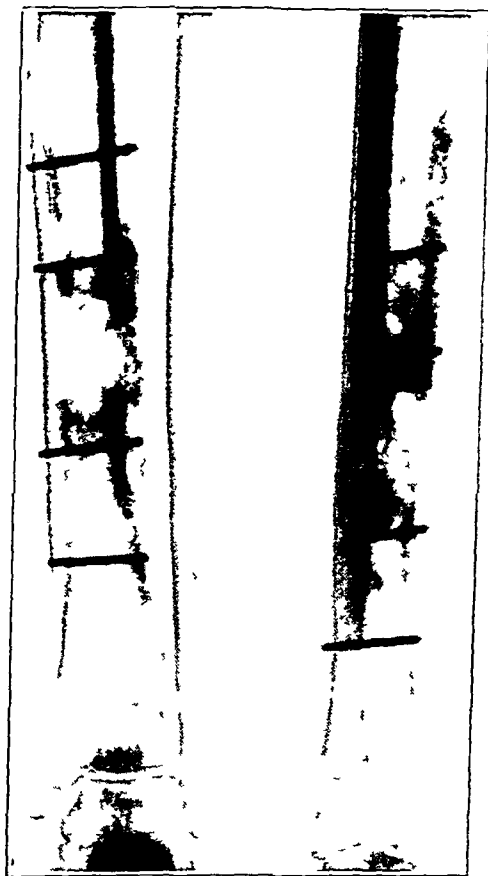


Figure 15

Fig. 14—Roentgenogram in case H. B. (fig. 13) immediately after application of a double onlay cortical graft (Bovd. H. B. J. Bone & Joint Surg. 23:497, 1941) fixed with four threaded wires, transfixing the shaft and both grafts. Unsatisfactory ends of bone were resected and the defect was packed with cancellous iliac chips.

Fig. 15—Appearance in case H. B. (figs. 13 and 14) after eight months. Beginning of bony union seems certain. The wires have held well. The plaster cast is still being used.

run into the difficulty often encountered in getting the right length, and this must appeal to them as a useful method in internal fixation.

It appeals to me particularly for fractures of the internal malleolus of the ankle. When he fixed one of these back, I wondered whether he was encroaching on the articular space of the ankle, because such a small fragment of bone can start the screw through.

I should like to ask Dr McCarroll whether he has used this method of immobilization in fractures of tibial tuberosities which require fixation and whether or not it works in this area. It would seem to me without having had any

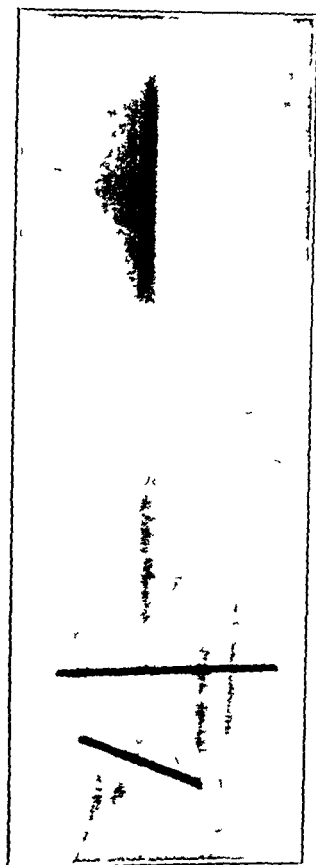


Figure 16

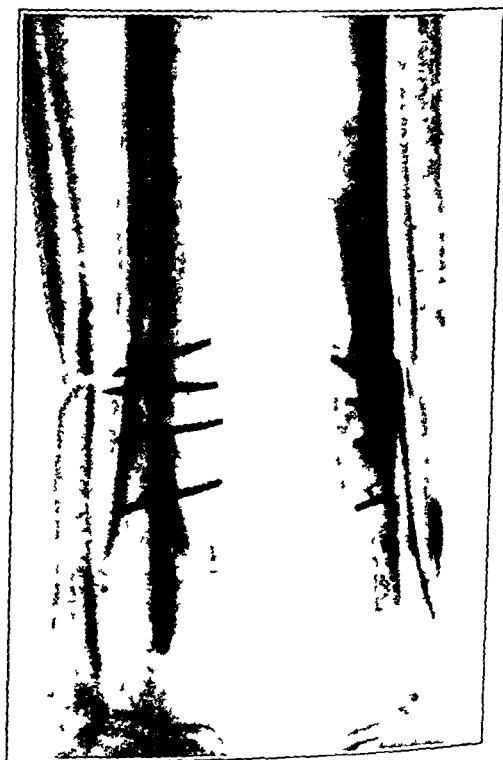


Figure 17

Fig 16 (case 23) —Spiral fracture of the tibia with the fibula fractured at a higher level in a patient aged 44 years. Open reduction and fixation were done with two threaded wires without preliminary drilling. Fixation was therefore insecure and the fragments slipped. This shows malposition after displacement occurred. One wire had been left long for later removal. Nonunion resulted.

Fig 17—A second open reduction in case 23 (fig 16) was performed two months later. A large intramedullary graft was used being driven from above downward. Fixation was done with four threaded wires. Three barrel stave grafts (Steele) were also used. This shows the degree of union present 10 months after bone graft. Note the osteotomy of the fibula.

experience with the threaded wire that in drilling its own way through the thinned-out cortex in the tibial tuberosities it might not work.

I also think that in demineralized bone or bone grafts possibly I would feel more secure in using a screw fixation with a flat head which will lead to a good dead or compression.

I am sure that with the use of this little threaded wire there are many tricks in inserting it and it is not so simple as it looks. I know that in Dr. McCarroll's hands it is probably extremely simple and I know that he knows all the difficulties about getting it into the bone. I wish that he would mention some of these when he closes the discussion.

DR. WILLIAM J. SCHULTZ, Chicago. In association with Dr. Edward L. Conner, I have used the threaded wires a great deal. We have found them extremely satisfactory and efficient for the multiple uses that Dr. McCarroll has discussed. In addition we have found them valuable in fractures involving the tibial tuberosities and in fractures of the hip. Only in 2 of our cases have we had any difficulty with the wires. In 1 case a wire migrated into the pelvis and had to be removed. In a second case one of the wires broke in the midportion of a femoral neck.

I feel that in the cases of oblique or spiral oblique fractures of the tibia transfixation screws are much more valuable than the threaded wires because of their impacting and compression forces.

One of the most valuable uses of the threaded wires is in the internal fixation of the fractures of the neck of the femur in elderly persons especially those who present poor risks. These threaded wires can be rapidly put into place with an automatic screw driver without any incision being necessary and by using local infiltration anesthesia entirely. The procedure requires a total of two anterior-posterior and two lateral roentgenograms of the hip and takes about twenty to twenty-five minutes of time in the operating room.

It is important to remember that these threaded wires are used for internal fixation only and not for support.

DR. H. H. STRYKER, Kalamazoo, Mich. My associates and I have found these wires useful in fractures of the bones of the hand and fingers. The wires inserted for fixation are cut off flush with the skin and the skin is pulled over the end of the wire. When sufficient time has elapsed for healing of the fracture, the wire which can be palpated beneath the skin is removed. This lessens the danger of infection, and motion can be started earlier. In fractured metacarpals several wires are placed transversely fixing the fractured bone parallel to the adjacent metacarpals.

DR. H. RELTON MCCARROLL, St. Louis. These small threaded wires must be simple if I can use them. I do not think that there is anything extremely difficult about putting them in. Their simplicity is such that no great difficulty has been encountered in their application. Preliminary drilling for these wires is not required in the cancellous portion of the bone but the wire in such instances must be pointed. For fixation of onlay bone grafts or for fixation of any heavy cortical bone preliminary drilling must be used; a smaller drill point is necessary for this.

As to their use in the metacarpals the threaded wires have been used in many types of fractures that I was unable to show. They have been used in fractures and dislocations of the metacarpals and in fractures of the metatarsal bones. I have used it in 1 instance through the articular surface but prefer to place the wire alongside the articular margin if at all possible.

In regard to Dr King's remarks, I assume that he is talking about the two fractures of the shoulder. Although they appear in the roentgenogram to have crossed the articular surface, they were entirely outside the margin of the joint. These wires were passed through the tuberosity of the humerus, anterior or lateral to the articular surface and the acromion process.

As regards fractures of the tuberosity of the tibia, none have been encountered since the use of the threaded wire was instituted, in which open reduction has seemed essential. I believe that the threaded wire would be entirely satisfactory for this type of fracture. It has been used in tibial tubercle transplants and has worked satisfactorily for that purpose.

Another point brought up is the question of the relative fixation of bone grafts. I am not advocating the use of the threaded wires for fixation of onlay grafts to the complete exclusion of screw fixation. All I can state is that in the cases in which threaded wires have been used excellent fixation has been afforded with no loss of position in any case. In my estimation the threaded wire holds just as well as the screw.

For the average surgeon in certain selected cases, I believe that the threaded wire will be found a useful means of fracture fixation.

TREATMENT OF DEEP VENOUS THROMBOSIS WITH REFERENCE TO SUBCUTANEOUS INJECTION OF HEPARIN AND USE OF DICUMAROL

WILLIAM D. HOLDEN, M.D.
CLEVELAND

DURING the past decade the practical use of venous ligation, anesthesia of the paravertebral lumbar sympathetic system and the anticoagulants has awakened interest in the therapy of deep venous thrombosis. Prior to this period, treatment consisted in rest in bed, elevation of the extremity involved and the application of heat. There has been some confusion in the literature as to the indications for the various types of therapy that are available today. The enthusiasm of various clinics for one of the three therapeutic agents has created a considerable ambiguity in the minds of many physicians as to the benefit derived from the use of any one of them. There does not appear to be any reason for such confusion. None of the three methods, i.e., anticoagulant therapy, paravertebral block or venous ligation is a panacea for venous thrombosis. The application of a few well known and well comprehended physiologic principles and clinical facts will perhaps simplify the problem.

The object in treating deep venous thrombosis of the lower extremities and pelvis is to prevent the occurrence of pulmonary emboli and to minimize the late effects of venous obstruction. It is also desirable to accomplish these ends with as little discomfort, danger and expense to the patient as is possible in attaining the foregoing objectives. To accomplish these ends, all methods of therapy should be utilized according to the indications in each patient. This attitude has been expressed before by de Takats and Fowler.¹

PARAVERTEBRAL BLOCK

DeBakey, Burch and Ochsner² have shown experimentally that arteriospasm can result from the inflammation of an adjacent vein.

From the Department of Surgery, Western Reserve University School of Medicine and University Hospitals.

1 de Takats, G. and Fowler, E. F. The Problem of Thromboembolism. *Surgery* **17**: 153 (Feb.) 1945.

2 DeBakey, M., Burch, G. E. and Ochsner, A. Effect of Chemical Irritation of Venous Segment on Peripheral Pulse Volumes. *Proc. Soc. Exper. Biol. & Med.* **41**: 585 (June) 1939.

The cold perspiring extremity with diminished temperature of the skin and reduced oscillometric index is seen in venous thrombosis. Commoner, perhaps, is the warm dry extremity with generalized vasodilation and increased amplitude of the pulse. Papper³ has demonstrated that venospasm accompanies thrombophlebitis. Venograms performed early in the course of thrombosis of the veins in the calf often show segments of narrowing which, when correlated with the clinical observations can best be interpreted as being due to venospasm.⁴ Elevation of venous pressure is not infrequently present in the lower extremity by the time clinical manifestations of venous obstruction are apparent.⁵ Both arteriospasm and venospasm associated with venous thrombosis can be abolished by paravertebral lumbar block.

VENOUS LIGATION

Ligation of the superficial and common femoral veins, the iliac veins and the vena cava has proved to be of immense value in reducing the incidence of pulmonary infarction.⁶ The indications for ligating the superficial femoral veins are clear and those for the more proximal veins ambiguous. When thrombosis of the veins of the lower extremity has not extended clinically beyond the lower portion of the superficial femoral vein, ligation of that vein bilaterally just below its junction with the profunda femoral offers the best opportunity of preventing the occurrence of a pulmonary embolus. The vein is always opened before ligation to determine the presence or absence of a free thrombus. Edema of the thigh, which in its early stages can be determined only by actual measurement, and tenderness along the course of the femoral vessels should lead the surgeon to expect an attached thrombus in the femoral vein. When such clinical observations are made, thrombectomy and ligation are not attempted. The indications for ligation of the veins more proximal than the superficial femoral are not clear, and, in view of the magnitude of the operations and the too frequent occurrence of persistent edema, these operations should be performed only after more conservative measures appear to be inadequate. A patient with

3 Papper, E. M. and Imler, A. E. The Use of Phlebography and Lumbar Sympathetic Block in the Diagnosis of Venospasm of the Lower Extremities. *Surgery* **15** 402 (March) 1944.

4 de Sousa Pereira, A. The Innervation of the Veins. *Surgery* **19** 751 (May) 1946.

5 Ochsner, A. and DeBakey, M. Thrombophlebitis. The Role of Venospasm in the Production of the Clinical Manifestations, *J. A. M. A.* **114** 117 (Jan 13) 1940. Tyson, M. D. and Goodlet, W. C. Venous Pressure in Disorders of Venous System of Lower Extremities. *Surgery* **18** 669 (Dec.) 1947.

6 Allen, A. W., Linton, R. R., and Donaldson, G. A. Venous Thrombosis and Pulmonary Embolism. Further Experience with Thrombectomy and Femoral Vein Interruption, *J. A. M. A.* **128** 397 (June 9) 1945.

septic thrombophlebitis of the pelvic veins may require caval or iliac ligation but in my limited experience these patients have responded satisfactorily to intensive anticoagulant and antibiotic therapy. If caval or iliac ligations are to be performed they should be done by surgeons experienced in vascular surgery as Homans⁷ has advised.

ANTICOAGULANTS

In 1933 when Charles and Scott⁸ made available for practical clinical use the anticoagulant heparin an agent was presented that has proved to be invaluable in the therapy of venous thrombosis. Experimental evidence by Best and his associates⁹ and Hedenius and Wilander¹⁰ showed that this purified preparation of heparin had no adverse effect on the constituents of the blood or the physiologic processes of the experimental animal and the human being. It was further shown that heparin would prolong the clotting time and actually prevent thrombus formation when given intravenously in adequate amounts. It is generally accepted that heparin arrests the propagation of a thrombus in a patient with venous thrombosis. That this is of importance in minimizing the postphlebotic edema pain ulceration and induration has not been definitely decided. There is clinical evidence¹¹ to show that the incidence of pulmonary infarction is reduced by either the prophylactic or the therapeutic administration of heparin. It is also the impression of the physicians who have used heparin most extensively that the postphlebotic sequelae are minimized.

In 1944 Loewe¹² reported 15 patients who had been treated with subcutaneous administration of heparin. One hundred and twenty-five patients with thromboembolic disease treated with the heparin-Pitkin

7 Homans J. Medical Progress. Diseases of the Veins. New England J Med **235** 163 (Aug 1) 1946.

8 Charles A F and Scott D A. The Preparation of Heparin. J Biol Chem **102** 425 (Oct) 1933.

9 Best C H, Cowan C and MacLean D W. Heparin and the Formation of White Thrombi. J Physiol **92** 20 (Feb) 1938. Murray D W, G Jacques L B, Perrett T S and Best C H. Heparin and the Thrombosis of Veins Following Injury. Surg **2** 163 (Aug) 1937.

10 Hedenius P and Wilander O. The Influence of Intravenous Injections of Heparin in Man on the Time of Coagulation. Acta med Scandinav **88** 443 1936.

11 Murray G. Heparin in Surgical Treatment of Blood Vessels. Arch Surg **40** 307 (Feb) 1940. Bauer G. Heparin Therapy in Acute Deep Venous Thrombosis. J A M A **131** 196 (May 18) 1946. Cratoord C and Jorpes E. Heparin as a Prophylactic Against Thrombosis. *ibid* **116** 2831 (June 28) 1941.

12 Loewe L and Rosenblatt P. A New Practical Method for Subcutaneous Administration of Heparin. Am J M Sc **208** 54 (July) 1944.

menstruum were reported in 1946 by the same author¹³ (Pitkin menstruum consists of gelatin 15 to 30 per cent, dextrose 5 to 12 per cent glacial acetic acid 0.5 per cent and sufficient distilled water to make 100 per cent). The intravenous administration of heparin has been difficult because of the necessity of frequent determinations of the clotting time, the repeated intravenous injections and the maintenance of a constant intravenous infusion. The heparin-Pitkin menstruum, which is given subcutaneously, offers a more practical method of administration. The pain and tenderness to which most patients object following the subcutaneous injection constitute the only adverse quality of the preparation that I have encountered.

The anticoagulant dicumarol has been shown to be effective in preventing the occurrence of postoperative venous thrombosis¹⁴. The difficulty of regulating the dose of dicumarol has not been completely overcome and the exact action of dicumarol in the human being is not well understood in spite of the extensive investigations concerning its effect and action in the experimental animal. The most effective level of the prothrombin clotting time is not known. The Mayo group stated the belief that it should approximate 20 per cent of normal. De Takats maintains a level between 30 and 50 per cent of normal. It is my belief that beneficial effects, i. e. cessation of the propagation of a thrombus, are realized when the prothrombin clotting time is between 30 and 50 per cent of normal. At this level, however, there is no prolongation of the actual clotting time.

Of the last 37 patients with thromboembolic disease treated at University Hospitals 31 received heparin and dicumarol (3,3'-methylene bis-[4-hydroxycoumarin]) subcutaneously. Of these 31 patients 5 had ligations of the superficial femoral vein and 3 had paravertebral blocks for persistent arteriospasm in addition to the anticoagulants. Sixteen of the 31 patients had had pulmonary infarcts when the diagnosis of peripheral venous thrombosis was made. Two of the 31 patients had sublethal infarcts within forty-eight hours after the onset of anticoagulant therapy. All 31 patients recovered.

The 6 patients who did not receive anticoagulants had ligations of the femoral vein and paravertebral blocks. One of these 6 patients died six days following a bilateral ligation of the superficial femoral vein performed for a thrombosis of the veins in the calf of the left leg. Death was apparently caused by a massive pulmonary embolus but no autopsy was obtained.

13 Loewe L, Rosenblatt P and Hirsch E. Venous Thromboembolic Disease. *J. A. M. A.* **130** 386 (Feb 16) 1946.

14 Barker, N. W., Cromer, H. E., Hurn, M. and Waugh, J. M. The Use of Dicumarol in the Prevention of Postoperative Thrombosis and Embolism with Special Reference to Dosage and Safe Administration. *Surgery* **17** 277 (Feb) 1945.

When the diagnosis of venous thrombosis is made an evaluation of the extent and location of the thrombotic process is made. If the process is clinically confined to the popliteal and calf veins, a bilateral ligation of the superficial femoral vein is immediately performed with the patient under either local or intravenous pentothal sodium anesthesia according to the general condition of the patient. Whether ligation is performed or not 300 to 400 mg. of the heparin-Pitkin menstruum is given subcutaneously after the clotting time is determined and provided there is no contraindication to anticoagulant therapy. If the operation has been performed this is given at its termination. After the prothrombin clotting time has been determined 300 mg. of dicumarol is given. The base level of the prothrombin clotting time is especially necessary in cardiac, diabetic, malnourished and elderly patients and those recently operated on. If the initial level is below 100 per cent of normal modified doses of dicumarol are administered. No anticoagulants are given to patients with any hemorrhagic disease or hepatic or renal insufficiency. Patients with a history of a recently bleeding peptic ulcer or patients immediately before or after parturition are not given anticoagulants.

When the anticoagulants are used heparin should be given subcutaneously immediately. Prolongation of the clotting time is effected within one to two hours. The clotting time in my patients twenty-four hours after administration has varied between eighteen and fifty-five minutes. It is rarely over twenty minutes at the end of forty-eight hours. Clotting times are determined by the Lee-White method. To use dicumarol alone without heparin in the treatment of venous thrombosis is not justified, since the effect of the former is not apparent for forty-eight hours. It has been my experience that most of the pain in the extremities is absent or minimal within forty-eight hours after anticoagulant therapy is started. If the pain is not promptly relieved there is no hesitation in blocking the lumbar sympathetic chain.

SUMMARY

A plan for the treatment of venous thrombosis is presented embracing the physiologic principles underlying the use of and the indications for anticoagulant therapy, venous ligation and anesthesia of the paravertebral sympathetic system.

Sixteen of 31 patients with venous thrombosis had pulmonary infarcts before the diagnosis of peripheral venous thrombosis was made. All 31 patients were treated primarily with subcutaneous administration of heparin and dicumarol. Five of the 31 patients had ligations of the superficial femoral vein and 3 had paravertebral sympathetic blocks. All recovered.

PATHOGNOMONIC SIGN FOR CYST OF THE KNEE CARTILAGE

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IN 1938, while on Dr. Arthur Kridas's Orthopedic Service at Bellevue Hospital, I removed a cyst of the medial meniscus. It was observed at that time that the hemispherical cystic mass disappeared into the knee

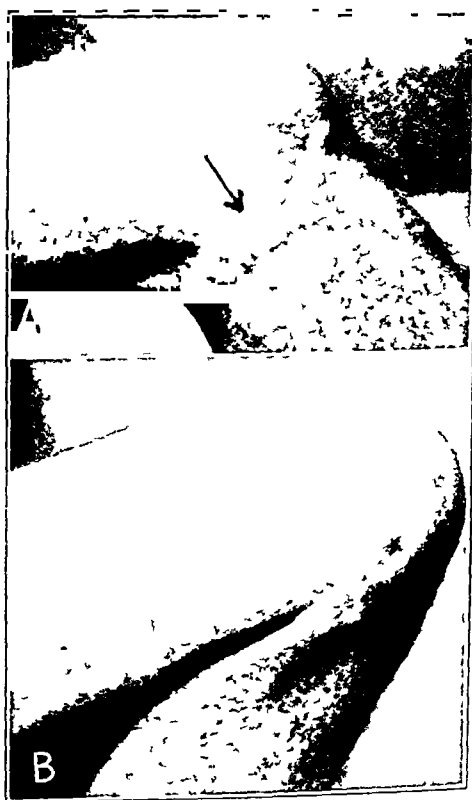


Fig. 1—A, cystic mass at the level of the joint cleft at 60 degrees. B, disappearance of the cystic mass on acute flexion.

joint on acute flexion and reappeared on extension of the knee reaching its maximum dimensions at a point 25 to 30 degrees short of complete extension.

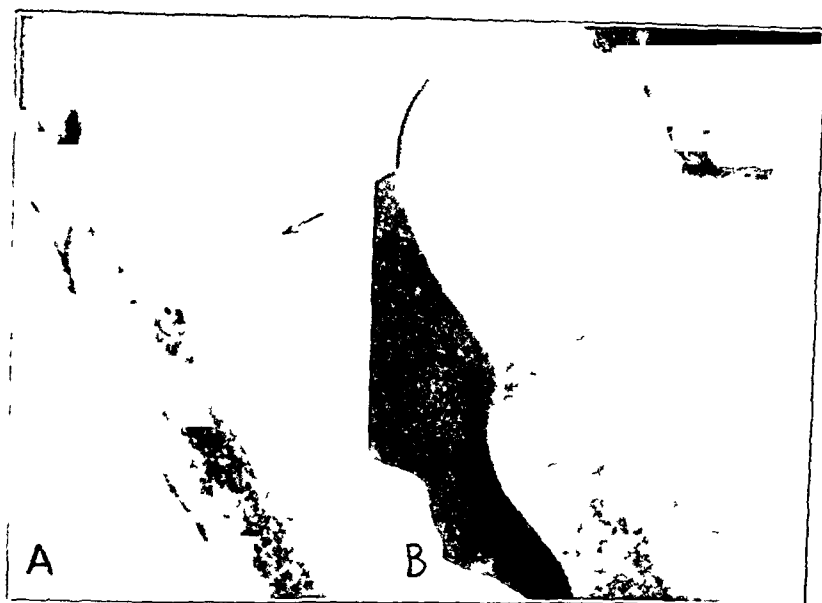


Fig 2—A cystic mass on extension B the disappearing sign

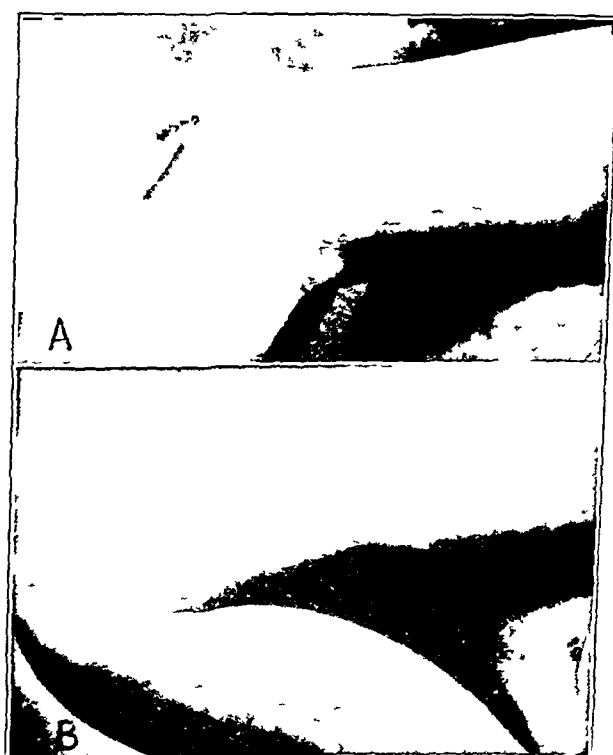


Fig 3—A cyst appears on incomplete extension B cystic mass has rotated into knee joint in flexed position

In 1943 I presented before the Canal Zone's Isthmian Medical Society a series of twelve cysts of the knee cartilages, both internal and external. The pathognomonic "disappearing sign" was described as a common finding in each of the patients operated on by Lieutenant Colonel Marcus Schwartz and me.

During the past three years eighteen more cysts of the medial and lateral menisci have been diagnosed and fifteen of them excised. In each of this last series the physical sign was present *viz*, disappearance on acute flexion and reappearance on extension.



Fig 4—*A*, lipoma with the knee in extension. *B*, lipoma with the knee in flexion.

In figures 1 *A*, 2 *A* and 3 *A* the firm tumor mass appears on extension of the knee in each case. On acute flexion of the knees (figs 1 *B*, 2 *B* and 3 *B*) the hemispherical cystic mass disappears due to a rotation of the tibias. Figure 4 illustrates a lipoma of the lateral aspect of the knee. Its position is just above the joint cleft, and it remains prominent even on acute flexion.

SUMMARY

Thirty-one cysts of the menisci are presented. The common denominator in all cases was the physical sign of disappearance of the mass on acute flexion of the knee and reappearance on extension. The sign is pathognomonic for cysts of the knee cartilage.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy
of Orthopaedic Surgeons

IV CONDITIONS INVOLVING THE HIP JOINT

PREPARED BY

JOHN J. FAHEY, M.D.

CHICAGO

(Continued from Page 11)

Fresh Fractures of the Neck of the Femur — Whitman⁷⁵ states the belief that internal fixation of fractures of the femoral neck should be classified as a complement to the abduction method of treatment. Functional activity may predispose to necrosis of the head and shortening of the femoral neck is not unusual in conditions treated by internal fixation. A number of cases have been reported in which spontaneous extrusion of the nail has resulted in union. Whitman directs a pessimistic outlook on patients treated by internal fixation, based on the statistics of Hew Groves in which only 50 per cent of the bones in 75 cases united.

[ED. NOTE (J. J. I.) — The author's opinion as to the merit of internal fixation versus the abduction method is in contrast to the present day reports and a study previously conducted by the American Academy of Orthopaedic Surgeons.]

Harmon⁷⁶ describes a new type of threaded, stainless steel screw to fix fractures of the femoral neck. The advantage of screw fixation is that it maintains impaction. The results in 35 cases of fresh transcervical fractures include satisfactory union with a viable head in 88.6 per cent of the cases. There were no fatalities and no cases of necrosis of the femoral head observed from one to three years. Results in 45 cases of trochanteric fractures treated by internal fixation showed satisfactory union without shortening in 88.8 per cent and a mortality rate of 11.1 per cent.

Weinberger⁷⁷ discusses stress lines in mediocervical fractures of the neck of the femur and demonstrated that Godoy Moreira's technic

75 Whitman, R. A Retrospective Commentary on the Campaign for the Establishment of the Positive Standard of Treatment for Fracture of the Neck of the Femur. *J. Bone & Joint Surg.* 27: 334-339 (April) 1945.

76 Harmon, P. H. The Fixation of Fractures of the Upper Femur and Hip with Threaded Hexagon-Headed Stainless-Steel Screws of Fixed Length. *J. Bone & Joint Surg.* 27: 128-137 (Jan.) 1945.

77 Weinberger, M. Resultados tardios de seis observações de fraturas de colo femoral por adução tratadas pela osteo-síntese-extra-articular com prótese do Prof. Godoy Moreira. *Rev. Brasil. de Cir.* 13: 401-418 (Aug.) 1944.

permits modifications of these stress lines in such a way that an adduction fracture will approximate an abduction fracture, in which the chances for union are always good. Six cases of adduction fractures treated by this method with good results are described.

Wadstein⁷⁸ emphasizes the advantages of using a helicoid screw for fixation of fractures of the femoral neck. Seven of the 37 patients treated by this method died within six months after operation, and the 30 remaining patients secured a good osseous union.

According to Stuck,⁷⁹ fixation of fractures of the femoral neck can be accomplished by using the palpating finger on the line of fracture, so that no roentgenograms or guides are required. Through a lateral incision over the trochanter, the anterior aspect of the femoral neck is exposed by reflection of the anterior capsule. The reduction is checked by the finger, while an assistant makes traction on the leg and manipulates. A Smith-Petersen nail is then inserted, being aimed at the finger placed at the site of fracture. A pillow is placed under the extremity postoperatively to prevent internal rotation, and the patient is permitted to move freely in bed, although he is kept recumbent eight weeks. Stuck makes a plea for internal fixation of intertrochanteric fractures.

[ED NOTE (J J F) —It is not always easy to estimate the direction and penetration of the nail even with open reduction when roentgenologic control is not used.]

Leadbetter⁸⁰ is of the opinion that 90 per cent of fractures of the femoral neck can be reduced by the closed method, as advocated by him in 1933. The fixation of the femoral neck in the valgus position has had universal endorsement. He relies considerably on the clinical examination in determination of bony union, rather than using the roentgenogram as the sole determining factor.

Linton⁸¹ discusses the origin, prognosis and complications and treatment of intracapsular fractures of the femoral neck, based on an experience with 365 cases. One hundred and forty-five cases were followed for more than two years. Impacted fractures should be treated more frequently with recumbency. Adduction fractures have a poor

78 Wadstein, T. Osteosynthesis with Screws in Medial Fractures of Neck of Femur, *Acta orthop Scandinav* 14 251-269, 1943.

79 Stuck, W. G. Fractures of Hip as a Problem in Military Surgery, *Mil Surgeon* 96 58-64 (Jan) 1945.

80 Leadbetter, G. W. The Problem of the Fractured Hip, *Nebraska M J* 30 309-313 (Sept) 1945.

81 Linton, P. On Different Types of Intracapsular Fractures of Femoral Neck. Surgical Investigation of Origin, Treatment, Prognosis and Complications in 365 Cases. *Acta chir Scandinav* (supp 86) 90 1-122 1944.

prognosis a large number showing necrosis and pseudoarthrosis. Unfavorable factors were age, posterior defect, decided obliquity of the fractured surface and insufficient obliquity of the nail. Pseudoarthrosis following union was occasionally encountered. Union occurred in 83.6 per cent of the series and in 80.3 per cent of nailed adducted fractures.

Speed⁸² expresses the opinion that postoperative infections following internal fixation of the femoral neck are not so uncommon as the infrequency of reports would indicate. The onset is often insidious and not alarming. Loss of weight and strength, discharging sinuses and even dislocation of the hip may occur. Four patients referred to him after the onset of this complication were treated with favorable results. The fixing agent is removed and the femoral head excised. The neck is then placed in the acetabulum, the wound packed with petrolatum gauze and a body cast applied. He recommends use of large doses of penicillin.

[Ed. Note (J. I. F.)—The author emphasizes a complication that is too often ignored. This hazard is more frequent and serious in cases in which internal fixation is performed by open reduction.]

McElvenny,⁸³ in discussing fractures of the femoral neck, believes that the fate of the femoral head depends more on an adequate reduction than on an irreparable damage to its blood supply at the time of the fracture. He states the belief that many are pathologic in nature and that the fall is caused by the fracture. Open operation is necessary only in an occasional case. The author recommends preliminary Russell traction and encouraging the patient to move about in bed and turn from back to side every two hours, with a mattress protector placed between the rubber sheet and bed sheets, to prevent irritation of the skin. In about ten days, if the condition of the patient is satisfactory, operation is performed, pentothal sodium being used for induction and then 60 per cent nitrous oxide and 40 per cent oxygen anesthesia. The limb is pulled down in external rotation and slight abduction, and with traction still applied the hip is toggled until the neck passes the head and then the limb is adducted to neutral or slightly beyond. The patella should then face directly medially. The reduction is satisfactory when the limb is in complete internal rotation and the neck fragment is well under and well inside the head fragment as shown in the anteroposterior view and when there is no angulation between the head and the neck in the lateral view. A Smith-Petersen nail is threaded over a guide wire.

82 Speed, K. Treatment of Post-Operative Infections Following Internal Fixation for Fracture of the Neck of the Femur. *Surg. Gynec. & Obst.* 80: 479-484 (May) 1945.

83 McElvenny, R. T. Roentgenographic Interpretation of What Constitutes Adequate Reduction of Femoral Neck Fractures, *Surg. Gynec. & Obst.* 80: 97-105 (Jan.) 1945.

and, ideally, should enter the shaft at or below the level of the lesser trochanter, run through the lower one half of the neck and center the head in both planes. If the hip cannot be reduced satisfactorily, or at the first sign of failure, an intertrochanteric or subtrochanteric osteotomy should be performed immediately. In a series of 38 consecutive cases followed from eighteen months to four years, there were 4 cases of failure and only 1 death, which occurred three years following the fracture.

Birch-Jensen⁸⁴ reports on 63 cases of internal fixation for fractures of the femoral neck. In 10 cases of necrosis of the femoral head, the necrosis in 7 was detected more than twelve months subsequent to operation. Functional results were good in only 44 per cent of the cases. The period of observation was more than one year in all but 15 per cent of the cases.

Wardle,⁸⁵ after studying 50 cases of treated intracapsular fractures of the femoral neck, feels that pinning is indicated because it decreases the incidence of hypostatic pneumonia and sepsis from bed sores and gives freedom from immobilization, but he states the belief that the percentage of bony union is no greater than that obtained by immobilization in a cast. He is of the opinion that perforation of the guide wire through the articular cartilage, permitting synovial fluid to gain entrance through the channel of fixation, might account for the displacement of the nail in some cases. He suggests addition of a bone graft to the method of internal fixation.

[ED NOTE (J J F) —The advisability of placing a bone graft across the site of fracture at the time of internal fixation for fractures of the femoral neck might be questioned on the basis of increasing the operative hazard and the lack of evidence that it would actually increase the incidence of union.]

Virgin and MacAusland⁸⁶ have found a traction screw designed by one of the authors to be an efficient form of internal fixation. A special spring arrangement that provides for a take-up in the event of absorption about the line of fracture is described and the principle is illustrated by roentgenograms.

Haas⁸⁷ describes a case of longitudinal fracture of the femoral head associated with a dislocation treated by closed and later by open reduc-

84 Birch-Jensen, A. Resultate der Osteosynthese collis femoris a m. S. Johansson. *Acta chir. Scandinav.* **87** 433-440 1942.

85 Wardle, E. N. Subcapital Fractures of Femoral Neck. Fixation by Pin and Graft, *Lancet* **1** 399-402 (March 31) 1945.

86 Virgin, H. Jr and MacAusland W. R. A Continuous Traction Screw for Fixation of Fractures of Hip. Review of Twenty-Three Cases. *Ann. Surg.* **122** 59-67 (July) 1945.

87 Haas S. L. Longitudinal Fracture of Head of Femur Associated with Dislocation of Femur, *Am. J. Surg.* **69** 402-405 (Sept.) 1945.

tion with failure. Subsequently arthrodesis was performed, which did not result in complete consolidation; however, 40 degrees of painless motion was present. He feels that closed reduction should first be attempted in these cases and later open reduction or arthrodesis if necessary.

March Fractures of the Neck of the Femur—Gibbens⁸⁸ reports the case of march fracture of the femoral neck in a soldier who experienced sudden severe pain in his right hip while marching and was unable to bear weight. He was found to have muscle spasm on rotation and limited motion on extension. The initial roentgenogram showed only a loss of continuity of the cortical neck inferiorly. The line of fracture, however, was found to involve the entire neck three weeks subsequently.

Bingham⁸⁹ reports a case of a march fracture of the femoral neck in a youth 18 years of age resulting in a varus deformity, such as occurs typically in fractures due to gross violence. He thought that the case was unusual so far as the degree of displacement was concerned.

Intertrochanteric Fractures—Compere⁹⁰ is of the opinion that in intertrochanteric fractures death is more frequent than and poor results almost as common as those obtained in the treatment of fractures of the femoral neck. He feels that the common cause of deformity is usually too short a period of immobilization. If traction is used, it should be maintained for twelve weeks. He favors open reduction with use of the Compere plate and threaded pins. He feels that the chances of death, malunion, the evil sequelae of stiff knees and circulatory edema are minimized by internal fixation.

Gosse⁹¹ finds the mortality rate in intertrochanteric fractures higher than in those of the femoral neck. As a group, patients with intertrochanteric fractures are older, and there is more damage to the bone resulting in hemorrhage, pain and shock. He advocates internal fixation with the patient under local anesthesia for both types of fracture and treats them postoperatively with a bar fastened with plaster to the foot, to prevent external rotation.

[ED. NOTE (J. J. F.)—Traction during the first ten days to two weeks subsequent to operation seems indicated, and with the extremity resting on a pillow external rotation is usually controlled.]

88 Gibbens, M. E. March Fracture of the Neck of the Femur. A Case Report. *J. Bone & Joint Surg.* **27** 162-163 (Jan.) 1945.

89 Bingham, J. A. W. Stress Fracture of Femoral Neck. *Lancet* **2** 13-14 (July 7) 1945.

90 Compere, E. L. The Treatment of Intertrochanteric Fractures of the Femur, Mississippi Valley M. J. **67** 13-18 (Jan.) 1945.

91 Gosse, N. H. Fractures of Neck of Femur, Nova Scotia M. Bull. **23** 302-308 (Nov.) 1944.

Luskin⁹² found that aboard ship, where apparatus and beds are at a premium and evacuation and transportation are often emergencies, the simplest method for treating intertrochanteric fractures is reduction of the fracture by traction, insertion of pins through the lower end of each femur and a double hip spica cast incorporating the pins.

Cohn and Vonburg⁹³ discuss the merit of blade plate fixation of intertrochanteric fractures. They emphasize that failures may occur by this method in cases in which there is pronounced comminution of the greater trochanter or when the shaft and greater trochanter form a thin shell of bone.

Posch and Abbott⁹⁴ have studied the end results of fourteen intertrochanteric fractures treated by the hanging cast. Most of the fractures were so comminuted that nailing was thought inadvisable. There was only one death. The position in the remaining cases, as well as the hip motion, was good. The stiffness of the knee and ankle in most instances was corrected by physical therapy.

Nonunion—Hermann⁹⁵ reviews 8 cases of nonunited fractures of the hip treated by McMurray osteotomy and reported in 1941 and gives his experience in 11 more cases of such reconstructions done at the Boston City Hospital by various surgeons since that time. Five of the 8 patients originally reported and thought to have a satisfactory result were recently reexamined, and 2 of them were found to have lost some of their local hip motion and showed an increase in shortening because of some change in position of the distal fragment, due to lack of real bony union. Two patients died soon after operation, despite the apparent simplicity and shortness of the operation. One can expect 80 per cent to walk with a slight limp and to walk up and down stairs with a cane. Some have moderate pain at the end of a day and have difficulty in crossing their legs. The author feels that the operation is not so simple and non-shock-producing as originally thought, and candidates for the operation should have a fairly viable head and some femoral neck and must be a good surgical risk. The operation should not be universally adopted for nonunion, but the surgeon should choose the best-adapted procedure for each particular case.

Stewart⁹⁶ recommends screw fixation following osteotomy for ununited fractures of the neck of the femur, in order to eliminate immo-

92 Luskin, H. Intertrochanteric Fractures of the Femur. Early Care on a Hospital Ship. *U S Nav M Bull* 44:1221-1227 (June) 1945.

93 Cohn, B. N. E., and Vonburg, V. R. Surgical Treatment of Intertrochanteric Fractures. *Rocky Mountain M J* 42:587-592 (Aug.) 1945.

94 Posch, J. L., and Abbott, W. E. Treatment of Intertrochanteric Fractures of Femur. Use of Hanging Cast. *Am J Surg* 70:369-373 (Dec.) 1944.

95 Hermann, O. J. The McMurray Osteotomy for Nonunited Hip Fractures. *New England J Med* 232:186-189 (Feb. 15) 1945.

96 Stewart, J. D. Subtrochanteric Osteotomy for Treatment of Nonunion of Hip Fractures. *Northwest Med* 44:112-117 (April) 1945.

bilization in a cast and to permit early motion. Of 11 cases, the results were good in 4 fair in 3 poor in 2 and failures in 2.

[ED NOTE (J J F) —Screw fixation does not seem to be so effective for internal fixation following osteotomy as the Blount blade plate.]

Guilleminet⁹⁷ found osteotomy an effective procedure for congenital coxa vara. Anatomic and functional results two years subsequent to operation were good in a boy of 11½ years of age and a girl of 9 years.

Dislocation —Werneck⁹⁸ states the belief that dislocations of the hip are easy to reduce by manipulation only within the first forty-eight hours. Persistent dislocation is a serious handicap and surgical reposition frequently results in partial ankylosis. There are four types, namely, posterior, including iliac and sciatic types and anterior, including pubic and ischiopubic types. Reduction should not be attempted without anesthesia. The method of reduction is illustrated in the various types of dislocations.

Arthrodesis —Haggart's⁹⁹ experience with conservative treatment and arthroplasty for degenerative arthritis in the age group from 50 to 65 has not been satisfactory. Arthrodesis performed in two stages has given the most satisfactory results. Ten of 12 patients obtained bony ankylosis and complete relief of pain and ability to return to their previous activities. There were two failures. Patients with involvement of both hips are not suitable for arthrodesis. The operation is done in two stages. In the first operation, the excess bone and cartilage of the head of the femur are cut away by a chisel and completed by a cup reamer. Drill holes, 1/16 inch (0.16 cm), are made in the head by a motor-driven saw. A motor-driven burr is then used to remove the acetabular cartilage and a drill used to make multiple holes in the acetabulum. Approximately two weeks later, again with the patient under spinal anesthesia, a fracture table being used, a Smith-Petersen nail is threaded over a guide wire and inserted, as suggested by Watson-Jones.

[ED NOTE (J J F) —It would seem likely that the preliminary removal of the articular cartilage of the joint and drilling was a great aid in obtaining such a high percentage of successful unions.]

Karlen¹⁰⁰ employed various means of obtaining fusion in 47 cases of osteoarthritis of the hip and in 12 cases of septic sequelae of conditions

97 Guilleminet. Traitement chirurgical de la coxa-vara congenitale. *Lyon chir* 37:350-354, 1941-1942.

98 Werneck, C. Luxação coxo-femural. *Rev. brasil. med.* 1:1047-1049 (Dec) 1944.

99 Haggart, G. E. Degenerative Arthritis of the Hip Joint Treated by One or Two Stage Arthrodesis with Metal Fixation (Watson-Jones). *J. A. M. A.* 128:502-507 (June 16) 1945.

100 Karlen, A. Arthrodesis in Osteoarthritis of Hip and Septic Coxitis Sequels. *Acta chir. Scandinav.* 89:309-321 1943.

involving the hip. Of the patients operated on for osteoarthritis, bony ankylosis was obtained in 36, fibrous ankylosis in 4 and no consolidation in 6. One patient died of shock. In his series of 12 cases of septic sequelae of conditions involving the hip, bony fusion occurred in 10 and nonunion in 1 and there was 1 death.

Alulectomy—Mallet-Guy and de Mourgues¹⁰¹ describe the case of a 49 year old man treated for chronic arthritis of the hip by endopelvic section of the obturator nerve, resulting in freedom of pain and improvement of motion. There was no anesthesia on the internal aspect of the thigh. They cite the results of Tavernier who obtained good results in 9 cases of arthritis of the hip by section of the obturator nerve.

Cottini¹⁰² reviewed the literature on obturator neurectomy for arthritis deformans of the hip. It is advocated in cases in which surgical procedures are contraindicated, such as poor general condition, bilateral lesions and obesity, and in which there is contracture of the adductor muscles. Immediate results were encouraging, but as time progressed, symptoms usually recurred. Of 11 cases, the results were good in 5 and fair in 2. In 3 cases in which fibers of the femoral and sciatic nerves were sectioned in addition to the obturator nerve, the results were more encouraging.

After studying the results of radicotomy of the third, fourth and fifth lumbar roots, performed in 15 cases of arthritis deformans of the hip joint, Karlen¹⁰³ is of the opinion that the operation is of doubtful value. The results were good in 1 case and satisfactory in 7.

Osteoarthritis—Hermudsson¹⁰⁴ is of the opinion that the roentgenologic signs of osteoarthritis of the hip indicate a definite connection with the anatomic build of the joint. The importance of structural changes and stresses resulting from variation of the angle of the femoral neck is emphasized.

Wagh¹⁰⁵ found that the synovial fluid of the hip in cases of chronic osteoarthritis appeared to be consistently on the alkaline side.

101 Mallet-Guy, P., and de Mourgues, G. Arthrite chronique de la hanche traitée par section endopelvienne du nerf obturateur. *Ann chir* 37 262-264 1941-1942.

102 Cottini, G. F. El tratamiento del dolor en la artrosis deformante de cadera, por la neurectomia del obturador (operacion de Selig), *Bol y trib Soc argent de cirujanos* 6 336-358 1945. *Rev Asoc med argent* 59 884-891 (Aug 15) 1945.

103 Karlen, A. Division of Fourth Lumbar Nerve Root in Treatment of Arthritis Deformans of Hip. *Acta chir Scandinav* 90 410-418 1944.

104 Hermudsson, I. Different Types of Osteoarthritis in Hip Joint and Their Connection with Anatomical Conditions. Does There Exist Any Subtype of Coxae Acquisita? *Acta radiol* 25 527-550 1944.

105 Wagh, W. G. Monoarticular Osteoarthritis of Hip. Treatment by Acid Injection, *Brit M J* 1 873-874 (June 23) 1945.

The injection each week of 15 to 20 cc. of a solution of lactic acid of pH 5.8 together with procaine hydrochloride into and around the hip joint was followed by gradual exercises. He found improvement in 50 to 60 per cent of 26 consecutive patients treated by this method.

Watson Jones¹⁰⁶ has used the Smith-Petersen nail for arthrodesis of the hip in 135 cases of degenerative arthritis since 1931. Experience has shown that unless a hip is already extremely stiff arthrodesis with a nail alone is not adequate. He has found that by removal of the articular cartilage from the joint at the first stage and fixation at the second stage there was much less shock than with the combined intra-articular and extra-articular arthrodesis with an iliofemoral bone graft. He expresses the opinion that arthrodesis is the procedure of choice in unilateral involvement of the hip. In the same paper Pridie gives his experience in arthroplasty for arthritis of the hip. The operation was found to be poor in cases of ankylosing arthritis and aseptic necrosis.

Slipped Femoral Epiphysis—Green¹⁰⁷ analyzes a consecutive series of slipped femoral epiphyses of 26 patients with thirty-six hips involved. In hips with minimal displacement nailing without arthrotomy gave good results. In hips with minimal to moderate displacement the best results were obtained by a method of using a particular combination of traction and plaster fixation. Open reduction and fixation gave good results in hips with severe displacement provided certain technical criteria such as recognizing the vessels on the posterior-inferior portion of the neck and avoiding the severance of them at operation were observed. Closed manipulated reduction could not be recommended.

Moore¹⁰⁸ describes 2 cases of slipped femoral epiphyses that resulted in aseptic necrosis. In 1, bony union occurred and most of the articular cartilage remained alive, but the articular cartilage was narrowed as a result of degenerative changes and ossification in its deeper zone. In the other, there was nonunion and both the ossification center and the articular cartilage became necrotic. There was only a small portion of the epiphysis replaced by new bone, and the articular cartilage underwent absorption and fibrocartilaginous replacement or ossification during the process of repair. The author states that following interruption of the blood supply to the epiphysis in adolescence the overlying articular cartilage may remain viable or undergo partial or

106 Girdlestone G. R., Watson-Jones R., Slamm T. T. and Pridie K. H. in Discussion on Treatment of Unilateral Osteo-Arthritis of the Hip Joint. Proc. Roy. Soc. Med. **38** 363-368 (May) 1945.

107 Green W. T. Slipping of the Upper Femoral Epiphysis. Diagnostic and Therapeutic Considerations. Arch. Surg. **50** 19-33 (Jan.) 1945.

108 Moore, R. D. Aseptic Necrosis of the Capital Femoral Epiphysis Following Adolescent Epiphysiolysis. Surg. Gynec. & Obst. **80** 199-204 (Feb.) 1945.

complete necrosis, and in either instance degenerative or reparative changes result in reduction of depth of the articular cartilage. These changes are in contrast to those seen in Legg-Perthes disease, in which rapid growth of the living articular cartilage compensates for whatever absorption or ossification of the cartilage takes place following revascularization in the ossification center.

Arthroplasty—Fernandez¹⁰⁹ has used an approach between the tensor fascia and gluteus medius muscles to gain access to the hip for arthroplasties, arthrodesis, reconstructive operations like those of Whitman and Brackett and other conditions involving the region of the hip. Few vessels are encountered, and frequently the entire operation can be completed without ligation. The only anatomic obstacle to this operation is that one of the terminal branches to the tensor muscle from the superior gluteal nerve crosses the field.

[ED NOTE (I J F)]—The tensor and gluteal muscles are closely attached, and their separation usually causes bleeding from several small branches, which is not so easy to control as when the approach is made medial to the tensor muscle.]

Karlen,¹¹⁰ after studying 16 cases of arthroplasty performed for arthritis deformans, 7 with fascia lata and 9 with vitallium cups, concludes that in arthritis deformans of the hip joint the chance of a successful result from arthroplasty is small. The results were good in 2 cases and only fair in 5. Unsatisfactory results were obtained in patients over 30 years of age and those engaged in strenuous occupations. He feels that the operation should be used only when the patient is absolutely dependant on a movable joint for continuance of his occupation, and then it should be done with fascia lata.

[ED NOTE (I J F)]—It is generally felt that vitallium cups are superior to fascia lata and certain authors, having a large experience with fascia lata arthroplasties, have abandoned it in favor of vitallium cups. This article is one of the more pessimistic ones on arthroplasty.]

Batchelor¹¹¹ reports on 5 cases of ankylosing spondylitis of the hip and spine treated by excision of the head and neck of the femur. In 4 patients bilateral excision was performed. In 2 of these patients osteotomies were combined with the operation. He expresses the opinion that excision followed by osteotomy is indicated in patients who are

109 Fernández, L. L. Cadera y cuello del femur, su abordaje por la vía entre el tensor de la fascia lata y el glúteo medio. *Prensa med. argent.* **32**: 127-129 (Jul. 6) 1945.

110 Karlen, A. Arthroplasty in Arthritis Deformans of Hip Joint. *Acta chir. Scandinav.* **90**: 482-494, 1944.

111 Batchelor, J. S. Excision of the Femoral Head and Neck in Cases of Ankylosis and Osteoarthritis of the Hip, *Proc. Roy. Soc. Med.* **38**: 689-690 (Oct.) 1945.

young and have a reasonable chance of returning to an active and useful life. In older patients in whom the chief purpose of treatment is to restore motion of the hip so as to allow them to sit comfortably about their home, excision is probably all that is required.

V CONDITIONS INVOLVING THE FOOT AND ANKLE

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State Strain on the Foot—Pemberton¹¹² reports on the care of soldiers' feet. He says that mild strain on the feet manifested only by pain in the feet and legs on walking plus tenderness, requires no treatment except proper fitting of shoes and foot hygiene. The commonest condition is faulty posture of the feet resulting in one of the several types of flatfoot. Treatment is directed at correction of the pronation. Mild conditions are treated with a 3/16 inch (0.48 cm.) inner heel wedge. A firm flexible arch support is used in severer conditions, with the high point under the sustentaculum tali. Steel arch supports have no place in the Army. The flexible support is made of shoe leather with properly fitted felt pads. For a congenital weak foot, flexible arch supports and taping are advised. Congenital flatfoot is not disabling and probably no more subject to strain than the "normal" foot. It should not be fitted with an arch support. Shoes with a sufficient width of the shank are advised. If the condition is symptomatic, there is no satisfactory treatment in the Army. Flatfoot in the Army should not be considered a pathologic entity of serious import. It is no more likely to be symptomatic than the foot with a longitudinal arch, and it is subject to strain in the same manner. Spastic flatfoot is easily recognized and is a serious disability not ordinarily compatible with full duty in the Army. Acute strains should be treated by rest and taping, as should tenosynovitis. More or less permanently disabling problems concerning the feet should not be treated in the Army, and these include pes cavus, hallux valgus, spastic flatfoot, either post-traumatic, gonorrheal or part of a generalized arthritic syndrome, paralytic foot, congenital deformity and multiple congenital hyperkeratosis.

[ED. NOTE—This is a report of what has been done for these conditions of the feet and likely what will be continued to be done in the Army. The paper is based on actual experience with soldiers who have had pedal disorders.]

112. Pemberton, P. A. The Care of Soldiers' Feet. Bull. U. S. Army M. Dept. January 1945, no. 84, pp. 110-117. Arch. Phys. Med. 26: 282-289 (Mar.) 1945.

Kark¹¹³ states that the cause of foot strain in the services is overuse fatigue of the muscles of the foot that support the body weight and consequent strain of the ligaments. The outstanding circumstance is a too rapid transference from relative inactivity to full stress of military life. The rubbing of the boot on a corn, blister, callosity or wart traumatic arthritis of a stubbed great toe and pain of an ingrown toe nail are all examples of conditions which may throw the foot out of its normal position. Under such conditions the muscles fatigue much more readily and foot strain is soon added as the major source of disability. Both sources of trouble require treatment. Varying degrees of Charlie Chaplin gait and poorly developed muscles of the trunk and limbs may throw the weight bearing out of alignment.

The author advises more instruction regarding foot hygiene and the immediate reporting of minor complaints in the foot. The treatment recommended for foot strain may be divided into three stages: (1) a period of absolute rest in bed (the average period is from two to five days), (2) a period of non-weight-bearing exercises with gradual progression (light massage and contrast baths are helpful) and (3) a period of weight-bearing exercises (again progress is graduated). At first the patient gets up only for the exercises; later he is up between exercises. Weight-bearing exercises are designed to correct stance and gait to achieve full muscular power in balance at rest and in propulsion. Persistent pain in the presence of improved muscle power and not stiffness, partial mobility or mild deformity, is regarded as the indication for manipulation. When manipulation is performed it is done according to the technic of Bankart.

The author chooses to regard the condition in all cases as primarily the result of overuse and muscular fatigue and to treat patients from this point of view. He states that the adoption of this attitude is emphatically indicated by almost uniform failure of boot wedges, bar and arch supports and the patent evidence that the minor operation on the feet in civilian practice produce major disability in service personnel. Adequate treatment of acute and chronic strain on the feet requires hospitalization of two to six weeks.

[ED. NOTE.—The problem of taking care of people in the service always has to do with whether or not they want to get well so that even minor disabilities, if treated surgically, may turn into major disabilities. We feel that nothing should be done to any of these persons unless it is sure that they want to get well, and then we think that proper conservative correction will relieve them and rehabilitate them in every case. Surgical procedures should be necessary only in cases . . .]

¹¹³ Kark W. Foot Strain in the Services. *J. Roy. Army Med. Corps* 83: 167-171 (Oct.) 1944.

when the condition to be corrected is one that will prevent the carrying out of proper conservative measures resulting in reestablishment of normal function.]

Hartley¹¹⁴ expresses the opinion that instruction of the soldier in correct walking is a necessary aid in the treatment of weak feet and a prophylaxis against foot strain in normal feet. Correct walking has a beneficial effect on the muscular, ligamentous and osseous support. In normal gait the swing is free at the hips, the weight is carried from the outer part of the heel, the os calcis being kept in varus, and the weight is carried along the outer border of the foot to the head of the fifth metatarsal and then across the metatarsal arch to the head of the first metatarsal. The great toe is directed forward or is slightly internally rotated. In cases of mild pes planus, correct walking is sufficient.

[ED. NOTE.—We agree definitely that correct walking is the best exercise. The only problem is that the abnormal foot has to be brought into normal position so that correct walking can be carried out.]

Daniels and Wilson¹¹⁵ report on a survey of complaints relating to the feet on road marches and state that the common types of complaints relating to the feet in the unseasoned troops of this study were pain in the achilles tendon, blisters, bony pain which is essentially metatarsalgia, and burning sensations of the plantar area. The authors felt that some of the causes of these common complaints regarding the feet based on observations during these marches were improper shoes, improperly fitted or conditioned shoes, lack of previous physical conditioning, broken or improperly fitted arch supports, improper socks, anatomic abnormalities of the feet and mycotic infections.

[ED. NOTE.—We think that this group would also improve by having correct gait, and we do not believe that a man should be expected to do active duty with arch supports.]

Splithoff¹¹⁶ gives a short discussion of weak feet in naval personnel and states that treatment consists essentially of proper footgear with added correction when indicated, exercises, massage and contrast baths.

[ED. NOTE.—We suggest that it might be more practical to carry out functional exercises primarily normal gait.]

King¹¹⁷ presents the classic picture of march fracture of the second, third or fourth metatarsal bones with metatarsalgia, limp, possible tenderness and redness and the latent roentgenologic changes

114 Hartley, J. Gait and the Soldier. Importance of Gait in Prevention and Cure of Foot Strain, *Mil. Surgeon* **96** 177-182 (Feb.) 1945.

115 Daniels, B. T. and Wilson, C. H. A Survey of Foot Complaints on Road Marches, *Mil. Surgeon* **97** 306-312 (Oct.) 1945.

116 Splithoff, C. A. Symptomatic Weak Feet in Naval Personnel, *U. S. Nav. M. Bull.* **44** 1045-1047 (May) 1945.

117 King, I. J. March Fracture, *Indust. Med.* **14** 8-10 (Jan.) 1945.

Histories of 2 typical cases of factory workers are given. If there is an alteration in the relationship of the bones of the foot such as in flatfoot, then it is conceivable that slight repeated bending forces might cause march fractures.

Eddy¹¹⁸ reports 3 cases of march fracture among women employees of a shell-loading plant during a period of only eighteen months. As is true in all injuries occurring at work, the question of compensability arises.

Trench Foot and Immersion Foot—White and Scoville¹¹⁹ consider two conditions, trench foot and, its sea-going counterpart immersion foot, both being caused by prolonged exposure of the dependent lower extremities to cold and moisture. Occasionally, when a man is forced to kneel or sit for prolonged periods on the bottom of a rubber raft the same condition is seen involving the knees and buttocks. Immersion foot and trench foot differ from frostbite simply because the tissues are not actually frozen. If trauma by walking occurs infection usually follows and it often ends in moist gangrene. After exposure at sea infection and gangrene are fortunately less frequent, because circumstances prevent trauma to the feet by ambulatory activity. When first seen after exposure, in either trench foot or immersion foot the feet are cadaveric in color, swollen and blistered. Massive gangrene from the ankle may appear imminent, but when there is no infection and proper treatment is administered the recovery capacity is amazing. Recovery takes place in two stages—an early hyperemic stage and a later period of fibrosis. If the exposure was prolonged, incapacity may be present in both phases.

In treating these patients, one must keep the patient off his feet and protect him against rupture of the blebs and the formation of pressure sores in the weight-bearing areas of the anesthetic skin. If streptococcal infection begins moist gangrene and loss of the leg are apt to follow. The general effects of cold should be combated by warming the body with blankets and hot water bottles and giving hot tea, coffee or soup internally. The injured feet must be kept cool while the body is warmed. A nutritious high protein, high vitamin diet should be given as soon as tolerated. If the vitality is low, plasma transfusion combat shock and hypoproteinemia are valuable. Elevating the feet helps drain edema fluid and shrinks the blisters. If gangrene is already developed the extremities can be saved usually by amputation.

¹¹⁸ Eddy, I. H. Ir. March Fracture in Industry. *Indus. Med.* 13 (Dec.) 1944.

¹¹⁹ White, J. C. and Scoville, W. B. Trench Foot and Immersion Foot. *New England J. Med.* 232: 415-422 (April 12) 1945.

amputation of the toes and distal portions of the foot. Early amputation of a leg is excusable only in fulminating lymphangitis, threatened septicaemia or gas gangrene. Sympathectomy is illogical in the early hyperemic stage. The authors express the opinion that unilateral sympathectomy should be tried in bilateral severe trench foot with atrophy, rigidity and fibrosis.

[ED. NOTE—This article is based on experience with trench foot and immersion foot during the war.]

Greene¹²⁰ enumerates several precautionary measures in equipment and care of the feet as preventives against the frequently avoidable trench foot. He makes some practical suggestions with regard to socks and the use of dries and recommends standing in dry trenches instead of wet trenches.

Friedman¹²¹ studied the morphologic changes in 14 cases of trench foot seen recently and found that usually the damaged portion of the foot was sharply demarcated from the leg at a level slightly below the malleoli. In a few cases gangrene was restricted to the toes but usually it involved the whole foot. In the early cases the capillaries and small vessels were decidedly engorged and the medium-sized vessels were dilated and thin walled. There was hemolysis in some small vessels. Numerous vessels contained agglutinative erythrocytic thrombi. Murid hemorrhage and inflammation of vessels but no periangitis, were observed. Forty days after the original injury almost all thrombi were already organized, and both arteries and veins showed the features of endangitis obliterans, even in tissues above the line of demarcation. Since blood flow in the deep portions of an extremity does not always parallel that in the tissues near the surface, the superficial hyperemia may not accurately reflect the state of the circulation in the muscle. The author questions whether the initial lesion is vascular or neural.

[ED. NOTE—It is possible that the nerve and vessels are affected directly and equally by the extreme exposure.]

Schechter and Ragan¹²² discuss the diagnostic value of ischemic pain in connection with trench foot. Vascular occlusion of the lower extremity by use of a 220 mm. mercury pressure in a pneumatic cuff on the thigh, with the resulting symptoms of pain, was used as a basis for the authors' opinion that the symptoms were due to ischemia.

120 Greene R. The Prophylaxis of Trench Foot. *Brit. M. J.* **1**: 270-271 (Feb. 24) 1945.

121 Friedman N. B. The Pathology of Trench Foot. *Am. J. Path.* **21**: 387-433 (May) 1945.

122 Schechter A. E. and Ragan C. A. Trench Foot. The Diagnostic Value of "Ischemic Pain." *Bull. U. S. Army M. Dept.* June 1945 no. 89 pp. 98-100.

Patterson and Anderson¹²³ discuss war casualties from prolonged exposure to wet and cold, and they feel that length of exposure was not the main factor in determination of the severity of the lesion. Many variations in individual susceptibility to cold and wet were noted. Susceptible persons were those with previous injuries of the feet or legs, those with signs or symptoms indicating vasomotor instability, those with any suggestion of peripheral vascular disease and those with infections of the feet. Treatment was by mechanical respiration and oxygen therapy. Alternate positive (plus 4 mm of mercury) and negative (minus 10 mm of mercury) pressure at the rate of 18 respirations per minute was applied to the thorax, and oxygen was administered at the rate of 3 to 5 liters per minute for one hour once or twice daily. It is claimed that this treatment improves lymphatic drainage and venous return to the heart and increases cardiac output. A steeper pressure gradient between arterioles and venules results and blood flow through the chilled feet is thus improved. If employed in the early stages this treatment appeared to have a beneficial effect.

Most patients with gangrene did not remain dry, and a broad moist zone of demarcation formed. The nature of the bacterial flora found in the zone of demarcation varied considerably. Roentgenologic examination frequently revealed the presence of gas in the tissue. This was not necessarily the result of an anaerobic cellulitis but might be due to the retraction of dead tissues or their liquefaction by organisms other than clostridia. All patients in whom gas bacillus infection was suspected, in addition to sulfonamide drugs or penicillin or both were given prophylactic roentgenologic treatment. Amputation of toes should be done just distal to the apparent zone of demarcation. In some cases amputations of toes were performed without an anesthetic. If sepsis was present, the bone was not trimmed until later. Stumps healed well and granulating areas were prepared for early skin grafting by dressing with isotonic solution of sodium chloride and local chemotherapy.

In patients without gangrene, claw foot almost invariably developed. Damage to small muscles with unopposed action of the long flexor and extensor muscles of the toes and contractures in the muscles and soft tissues of the sole are considered to have been the cause of this deformity which, once established, remained as a permanent and severe disability. It is believed that the deformity could be reduced by the performance of suitable exercises and the use of foot supports in the acute and subacute phases of the disease.

[ED NOTE—This is an excellent paper on the subject.]

123 Patterson R. H. and Anderson F. M. War Casualties from Prolonged Exposure to Wet and Cold. *Surg. Gynec. & Obst.* 80:111 (Jan) 1945.

Hallux Valgus—McElvenny¹²⁴ divides his paper on hallux valgus into four parts. Part I is the introduction, part II describes simple exostectomy for relief of bunion pain. He feels that when correctly performed it is one of the most satisfactory operations for the relief of bunion pain. Its application is wide and it can be used more frequently than any other procedure. The causes are discussed at length and the author apparently believes that the greatest causative factor is a congenital abnormal displacement of the first metatarsal from the second (metatarsus primus varus). The involved anatomy is reviewed. He advises simple exostectomy as a satisfactory procedure for relief of pain especially in persons beyond the third decade of life, with mild to moderate degree of hallux valgus that does not require correction. In part III he describes the Silver procedure in detail, emphasizing that the crux of the operation is complete release of the adductor muscles to permit the varus position of the great toe without any tendency for recurrence of it into a valgus position. In part IV the Lapidus operation is described as an arthrodesis of the first metatarsocuneiform joint and the bases of the first and second metatarsals as a corrective procedure for the metatarsus varus in addition to a Silver type of capsuloplasty at the first metatarsophalangeal joint. The Lapidus operation is recommended for patients under 30 years.

Gottlieb¹²⁵ refers chiefly to cases of hallux valgus, wherein, he makes the point, correction of deformities of the second toe is necessary to prevent recurrence of the main condition. The second toe acts as a splint, and any flexion or extension, as in hammer toe, destroys this function. In correction of the second toe, whatever method is used, the digit is splinted in slightly flexed position.

Hawkins, Mitchell and Hedrick¹²⁶ express the opinion that the significance of the congenital varus deviation of the first metatarsal in the development of typical hallux valgus has been underestimated. They feel that correction should be by metatarsal osteotomy in all instances in which deviation of the first metatarsal is 10 degrees or more. They describe a double transverse shortening subcapital osteotomy to correct the varus deviation of the first metatarsal, in addition to a plastic repair of a medial capsuloperiosteal flap for correction of the hallux valgus through a curved incision in the skin. The bursa may or may not be excised, depending on the degree of irritative change. A Y-shaped incision is then made through the capsule and periosteum of the meta-

124 McElvenny, R. T. A Study of Hallux Valgus. Its Cause and Operative Management, Quart. Bull. Northwestern Univ. M. School **19** 94-101, 1945.

125 Gottlieb, A. Role of Second Toe in Bunions. J. Internat. Coll. Surgeons **8** 352-353 (July-Aug.) 1945.

126 Hawkins, F. B., Mitchell, C. L., and Hedrick, D. W. Correction of Hallux Valgus by Metatarsal Osteotomy. J. Bone & Joint Surg. **27** 387-394 (July) 1945.

tarsal shaft This flap is freed from the shaft, the base being left attached to the proximal phalanx The exostosis is excised cleanly, flush with the shaft Drill holes are placed through the metatarsal shaft in the antero-posterior plane near the medial cortex, about $\frac{1}{2}$ inch (1.27 cm) apart, the distal perforation being approximately $\frac{1}{2}$ inch proximal to the articular cartilage No. 3 chromic suture is then threaded through the drill holes The metatarsal shaft is doubly osteotomized perpendicular to the shaft with the power saw The interposing fragment, which should not exceed $\frac{1}{2}$ inch in breadth, is then removed The capital fragment is displaced laterally on the proximal one, the displacement being maintained by the spur on the distal fragment The heavy suture is then tied securely, the fragments being held in firm apposition The great toe is forcibly abducted and held in slight flexion while a plastic repair is performed on the capsuloperiosteal flap The V-shaped flap is sutured far proximal on the metatarsal shaft to maintain the toe in the overcorrected position Splints are reapplied firmly weekly for five weeks At that time the patient is ready to wear a straight last oxford Recently, weight bearing has been permitted four or five days after operation, the patient being encouraged to bear weight on the heels with the aid of crutches

[ED. NOTE—Even though we do not accept the theory of congenital varus of the first metatarsal as the etiologic factor, we think that it is advisable to correct it We feel that it is an acquired deformity.]

A history of a case is reviewed by Jackson,¹²⁷ to draw attention to the possible far-reaching effects of hallux rigidus With this case the author illustrates the importance of recognizing a stiff big toe as an occasionally disabling condition and also the importance of special investigation of the peripheral vascular system to exclude organic disease For ten months his patient was treated for thromboangitis obliterans when the correct diagnosis was bilateral hallux rigidus with congenital absence of the dorsalis pedis When bilateral, this is not uncommonly a congenital effect

The treatment of hallux rigidus by the conventional methods is unsatisfactory It is Jackson's opinion that the successful outcome in this case depended largely on the provision of adequate shoes Immediate provisional diagnosis was made of bilateral hallux rigidus with the changes of disuse, and the patient was encouraged to believe that he would get well The edema of the dorsum of the feet disappeared within two days of the patient's becoming ambulatory Pulsation in the posterior tibial arteries soon became constantly palpable, but the pulse of the dorsalis pedis were not felt A roentgenogram showed a

¹²⁷ Jackson, H. Hallux Rigidus Causing Intermittent Ischemic G. P. 4:417-420 (Sept.) 1945

arthritis of the first metatarsophalangeal joints and amputation of the distal ends of the terminal phalanges. Generalized rarefaction of the whole tarsus was so severe as to suggest a roentgenologic diagnosis of rheumatoid arthritis. Present findings gave no support to the previous diagnosis of thromboangitis obliterans. He was put on a pedaling machine and was given special shoes and active exercises were intensified. The patient was discharged to service leave after about two months and thereafter to duty. When seen about a year later he said that he frequently walked 10 miles (16 km) a day.

[**ED. NOTE**—We have had similar experiences in which we have seen patients with osteoporosis and vascular disturbances and conditions that have been diagnosed as thromboangitis obliterans who have recovered entirely by using the Thomas heel and the comma-shaped bar with the inclined planes plus reestablishment of normal gait.]

Stewart¹²⁸ recommends unshod feet in cases in which protection is not needed. A fully flexible upper with a toe guard if needed, omission of heels and shoes built for the individual foot, possibly by the use of plastics. He states that the shoe heel is essentially a prosthesis for a deformity. The effect of the heel on the normal physiology of the foot is (1) decrease to absence in the tone of the postural muscles, (2) increase of the tension in the plantar fascia, (3) shortening of the leverage of the foot for propulsion, which increases the required muscular effort in the push-off, (4) a decrease of the postural power of the erector muscles of the tibia, (5) keeping the toes in more or less complete dorsiflexion, which leads to contractures, (6) increase of the weight thrown on the articular surfaces of the metatarsal heads and (7) reversal of the position of the feet, which should spread, as they are dorsiflexed.

[**ED. NOTE**—This paper is interesting, but we question how practical it is.]

General—According to Meredith,¹²⁹ foot length doubles in the fourth prenatal month, during the three months before birth to six months after, during the first four years and from the middle of the second postnatal year to the age of 18. At birth, females have attained 34 per cent of adult foot length while males have obtained only 31 per cent. At 10 years the percentages are 90 per cent for females and 82 per cent for males. Means show that the feet of white North American college students are longer than they were fifty years ago. On the whole, mean foot length in adulthood is highest for Negroes, intermediate for white persons and lowest for American Indians. The author enumerates numerous other valuable and interesting statistics on the growth of the foot.

128 Stewart, S. F. Physiology of the Unshod and Shod Foot with an Evolutionary History of Footgear, *Am J Surg* 68:127-139 (April) 1945.

129 Meredith, H. V. Human Foot Length from Embryo to Adult, *Human Biol* 16:207-282 (Dec) 1944.

[ED NOTE—This article represents some original work, and we found it interesting.]

Kaplan and Symonds¹³⁰ used roentgen rays for determination of degree of flatness of the feet. The roentgenogram is taken from the inner to the outer aspect, and a tracing is made. A table of numerical ratios is given to indicate the degree of flatness.

[ED NOTE—We have tried to get some clinical help from measuring by roentgen rays, but with no success.]

Goff¹³¹ describes a technic of taking roentgenograms of the feet in weight-bearing positions. The article is accompanied with photographs of the apparatus, technic of procedure and roentgenograms.

Fischer and Van Demark¹³² present a rare bilateral symmetric shortening of the fourth metacarpal and fourth metatarsal in 1 person. These anomalies have a recessive hereditary basis. The association of the pigmentary areas with this anomaly in the authors' case emphasizes that neurofibromatosis may be associated with abnormalities of bone. Treatment is symptomatic to relieve altered mechanics.

Johnson¹³³ describes peritendinitis as a painful swelling over a tendon which corresponds to a point of pressure, such as from a fold in the leather of a boot, which causes a nodule over the achilles tendon, the tendon of the tibialis anterior muscle or the flexor tendon of the hallux. Stiffening the posterior portion of the shoe with a metal splint to protect the achilles tendon, altered lacing of the boot and protective felt pads causing the leather to fold outward are suggested as treatment. The author describes the nodule as occurring along tendons in the foot because of pressure and friction rub at circumscribed areas, due to creases in the boots of soldiers.

Jones¹³⁴ presents a case of rupture of the plantaris muscle, observed through a traumatic wound, as a result of an indirect stretching force which dorsiflexed the foot. The length of the muscle belly of the plantaris is only one fifth of the total length, and forces that so stretch the plantaris are more likely to rupture the belly portion because tension on the muscle belly is proportionately great.

130 Kaplan M. and Symonds, M. Pes Planus. A Method of Measurement. *Radiology* 44 355-356 (April) 1945

131 Goff, C. W. Roentgenography of Feet Under Weight Bearing Conditions. *Connecticut M. J.* 9 109-113 (Feb.) 1945

132 Fischer F. J., and Van Demark, R. E. Bilateral Symmetrical Pseudo-metacarpalia and Brachymetatarsalia. *J. Bone & Joint Surg.* 27 145-148 (July) 1945

133 Johnson H. D. Peritendinitis, or Foot-Slogger's Nodule. *Brit. M. J.* 1 193-194 (Feb. 10) 1945

134 Jones, G. B. The Pathology of the Ruptured Plantaris. *Brit. M. J.* 1 177 (June 23) 1945

A new instrument and simplified technic for the cure of ingrown nails is described by Whitesell.¹³⁵ The "shark fin" type of onychotome being employed the actual operative technic following nerve block about the base of the involved toe is as follows. With the blade parallel to the nail the instrument is forced proximal beneath the nail until the blade is under the eponychium. It is then rotated to the vertical, and the point is forced upward through the nail. As the instrument is withdrawn the nail splits evenly and cleanly. The eponychium is then freed from the segment being removed, and, the opposite or spatula-like end of the instrument being employed the nail segment is freed from its bed. Finally the blade of the instrument is employed to curet the matrix or nail-forming organ.

Chatterton and Blaisdell¹³⁶ have modified the Denis Browne splint for the treatment of clubfoot. The modification consists of a transverse steel rod about $\frac{7}{8}$ inch (1.6 cm) in diameter and length suitable to the size of the patient. To each end of this rod is welded a clamping mechanism which grips the soles of the shoes in the manner illustrated, much like roller or ice skates. In addition, posteriorly T straps are incorporated into the sole clamps. These straps are laced around the patient's ankles with regular shoe laces. In many cases the T straps may not be necessary, but they tend to prevent recurrence of the equinovarus deformity.

The advantages enumerated by the authors are these: 1. It can be applied to the shoes so that the corrective effect received with weight bearing is continued during non-weight-bearing periods. 2. No projections are present under the surface of the splint, so that the patient can stand in his crib without harming the bed clothing. 3. Only one pair of shoes is required at a time, which is important economically, since the shoes can be used for ordinary walking or standing when detached from the splint. 4. The splint is easily made and can be applied and removed in a few seconds.

Schmier¹³⁷ states that occasionally in spastic paraplegia the intrinsic muscles of the foot are involved, producing a hyperactivity of the intrinsic muscles with extreme flexion of the toes at the metatarsophalangeal joint and extension of the interphalangeal joints. The anatomy and intrinsic muscles of the foot innervated by the medial and lateral plantar nerves are described. Histories of 2 cases are given in which the operative technic is discussed in detail (neurotomy of the motor branches of

135 Whitesell, F. B. A New Instrument and a Simplified Technic for the Cure of Ingrown Nails, *Surgery* **18** 660-661 (Nov.) 1945

136 Chatterton, C. C., and Blaisdell, J. A Modification of the Denis Browne Splint, *J. Bone & Joint Surg.* **27** 518-519 (July) 1945

137 Schmier, A. A. Spastic Calcaneocavus Foot Deformity, *Am. J. Surg.* **68** 116-119 (April) 1945

the medial and lateral plantar nerves, incision of the plantar fascia near the os calcis, the Steindler stripping of the os calcis, and section of the tendons of the flexor brevis tendons with plantar capsulotomy of the first metatarsophalangeal joint)

[ED NOTE—It has been our experience that this usually occurs along with the equinus, and of course the equinus would lead to cavus deformity. Therefore it is not unusual to have to correct a cavus deformity in a spastic child.]

According to Woodland,¹³⁸ foot collapse is caused by overload or relative weakness of the foot. From the author's experience the commonest causes of functional insufficiency are the intrinsic factor of an unstable first metatarsal and the intrinsic factors of bad footwear, atonia of muscle and bad posture. The chief signs of full collapse of the foot are valgus at the heel, splay foot, supination of the forefoot, hallux valgus and contracted toes. The author shows in detail in his interpretation why once any of these signs appear the other signs can and will follow.

The foot is treated as a whole. Posture is corrected to achieve the optimum line of gravity. Rest, manipulation, contrast baths and radium baths are used to get the foot in condition for foot and walking exercises, to be performed twice daily for several months. The corrective shoe with a Hauser bar and a Thomas heel is used. In the first metatarsal is extremely inefficient, a "platform" on the inner sole beneath the head of the first metatarsal is used. Surgical measures are sometimes used as indicated. A Whitman brace is used in severe arthritis of midtarsal and subastragaloid joints.

Meyer¹³⁹ considers flatfoot a symptom of inherited weakness of connective tissue. He states the belief that latent thrombophlebitis in the deep veins of the leg and of the plantar veins plays the deciding role in the causation of painful flatfoot.

[ED NOTE—We think that the venous changes are secondary.]

For rigid arch supports, Street¹⁴⁰ recommends plexiglass, because of its durability, lightness, malleability and resistance to moisture. It is shaped to a plaster mold. A $\frac{3}{16}$ inch (0.48 cm) plexiglass is suggested for adults and a $\frac{1}{8}$ inch (0.32 cm) for children.

Hauser¹⁴¹ states that the commonest lesion of the subtalar joint is a displacement of the calcaneus laterally or a valgus deformity, due to

138 Woodland, L. J. Foot Collapse, *M. J. Australia* 2: 562-565 (No. 2.) 1944

139 Meyer, O. A New Treatment for Flatfoot and Other Common Foot Disabilities, *M. Rec.* 157: 732-733 (Dec.) 1944

140 Street, D. M. Plexiglass Arch Supports. *Air Surgeons Publ.* 2: 17 (April) 1945

141 Hauser, E. D. W. Management of Lesions of the Subtalar Joint. *S. C. North America* 25: 136-160 (Feb.) 1945

an imbalance between the demand made on the foot and the capacity of the foot to carry out the work required of it. This is the ordinary valgus deformity seen in pes valgoplatus as a result of prolonged strain on the foot. The retention of this position alters the relationship of the two articular surfaces of the subtalar joint. This position will cause a strain on the ligaments in this area and set up an inflammation within the articulation itself.

The principle of treatment consists in a realignment of the subastragalar articulation. This is done by placing the heel in varus and the anterior part of the foot in pronation, so that the inner side of the anterior part of the foot is at a lower level than the outer side. This position reestablishes the normal relationship in the subastragalar joint and maintains a normal height of the longitudinal arch. This normal weight-bearing position of the foot is retained with adhesive strapping, by felt pads in the shoes and/or by application of an inside lift to the heel and an outside lift to a comma-shaped bar on the sole of the shoe placed just posterior to the heads of the first four metatarsal bones. Walking with the foot in the aforementioned position is the most practical exercise. With reestablishment of proper gait, which consists in pulling oneself as tall as possible, keeping the feet straight ahead and placing the heel on the ground, with the foot in dorsiflexion, the patient rolls over the entire heel and gradually over the outer side of the foot and then pushes off the ground with the toes at the termination of the step. Habitual use of this gait insures retention of the subastragalar joint in a normal position and avoidance of symptomatic ligamentous strain and secondary arthrosis from malposition of this joint. Walking with this normal gait lessens fatigue and strengthens the muscular support of the foot, which increases the capacity of the foot for additional work.

Subtalar lesions due to anterior poliomyelitis result in instability of this joint due to loss of muscular support. An arthrodesis of the subtalar, talonavicular and calcaneocuboid articulations stabilizes the subtalar joint, prevents valgus position of the heel and eliminates the use of a brace.

Subtalar lesions due to fracture of the calcaneus produce disability because of the valgus position in the subtalar joint, with resultant pain and muscle spasm. Restoration of a normal position at the subtalar joint and of the anterior part of the foot which permits normal function also relieves pain. Fusion of the subtalar joint in a valgus position does not relieve pain. The principles and type of treatment following fractures of the calcaneus are similar to those for subtalar lesions due to static changes. The author reports asymptomatic conditions following fractures into the subtalar articulation and relief of pain secondary

to the valgus position of the subtalar articulation complicating these conditions after the valgus position is corrected and pain is relieved including 1 instance in which complete bony fusion existed in the subtalar articulation. This last case demonstrates that the cause of pain is not secondary to post-traumatic arthritic changes in the subtalar articulation. Roentgenograms and drawings demonstrating the use of the Haglund foot board and a manipulating wrench to obtain supination of the anterior portion of the foot and positions of the foot in casts accompany the article.

Fracture of the talus often disrupts the normal relationship of the bones and articular surfaces in the foot, producing friction rub, irritation, inflammation and arthrosis. Treatment requires reestablishment of the normal relationship of the articular surfaces in the same manner as fractures of the calcaneus that involve the subtalar joint. Lesions of the subtalar joint due to dislocation at the talocalcaneal joint are treated in a similar manner after reduction.

Lesions of the subtalar joint due to tuberculosis, chronic infectious arthritis and 1 case with an unknown causation are discussed. (The foregoing article was abstracted by Dr Robert P. Montgomery.)

Haxton¹⁴² writes that absolute muscle force is regarded as tension per unit of cross section of the muscle and is not dependent on the length. For these experiments force of plantar flexion was noted by upward pressure on the ball of the foot. Rapid readings were made by the use of the spring balance in the living subject. The physiologic cross section was determined in the cadaver of the calf muscles, and the results were compared with those of living subjects by direct ratio of the diameter of the calves of the living and cadaver subjects.

In his paper on recurrent dislocation of ankle due to rupture of the external lateral ligament, I believe that Hambly¹⁴³ refers to subluxation of the ankle joint due to poorly treated torn external lateral ligament. He repairs the ligament by splitting the peroneus longus tendon from above downward. One end is detached and threaded through the lateral malleolus to be fastened to the os calcis and then back again to be fastened onto itself, thus forming a new ligament.

[ED. NOTE—This is another technic for repairing this ligament. In most cases we feel that the weakness should not exist with proper care and frequently with conservative treatment, by increasing the support of the foot and the strength of the muscles that control the foot. All the symptoms will be relieved.]

142 Haxton H. A. Absolute Muscle Force in the Ankle Flexors. *J. Physiol.* **103** 267-273 (Dec 15) 1944.

143 Hambly, B. Recurrent Dislocation of Ankle Due to Rupture of External Lateral Ligament. *Brit. M. J.* **1** 413 (March 24) 1945.

Simon¹⁴⁴ states that in order to obtain an oblique roentgenographic view of the lower part of the fibula a special exposure is necessary. In figures shown the lateral malleolus is on the side of the roentgenogram, the heel is raised 4 cm. and the picture is made with the central ray directed from behind at an angle of 30 degrees.

Pratt⁴ discusses the etiology and chemistry of para-articular calcifications as well as the anatomy of the ankle joint. Serial roentgenograms serve to explain and aid in making a final diagnosis. There are two types of calcification: evulsive which appears fuzzy and has hazy margins with varying degrees of opacity in the adjacent connective tissues and tibialis which is a mature contracted well defined density.

Treatment is conservative immobilization and physical therapy. Sedation may be employed for pain. In instances of severe conditions anesthetic injections have been used, with good results. Irradiation therapy also has been used with favorable results. In most cases full function of the ankle is never restored, and calcification may persist and be followed by fusion. Although there have been reports of cases of spontaneous regression of calcium, they are rare.

Injection of Procaine Hydrochloride—Pendergrass and Lafferty¹⁴⁵ describe a type of dislocation of the ankle in which the usual anteroposterior and lateral roentgenograms appear normal. It is due to rupture or stretching of the external lateral ligaments of the ankle joint and is demonstrable in anteroposterior roentgenograms of the ankle in forced inversion, showing widening of the tibioastragalar joint space. Roentgenograms of normal ankles in inversion, eversion, flexion and extension are shown for comparison. The examination to determine mobility of the joint should be reserved as a supplementary procedure and not employed as a routine.

The manipulation of the joint is less painful for the patient if 5 or 10 cc. of procaine hydrochloride is injected around the point of maximum tenderness, although this is not essential. This type of examination is indicated in patients with a recurrent ankle sprain without severe pain, in those with a history of instability of the ankle, in those with abnormal motility of the ankle joint with a hollow instead of a swelling anterior to the external malleolus and in all patients with clinical symptoms suggesting more than a simple sprain in whom no evidence of bony injury can be found in the routine anterior, posterior and lateral roentgeno-

144 Simon, R. S. A Third Routine X-Ray Exposure of the Ankle Joint, *J. Bone & Joint Surg.* **27**: 520 (July) 1945.

145 Pratt, A. D. Post-Traumatic Para-Articular Calcifications and Ossifications of the Ankle, *Am. J. Roentgenol.* **54**: 348-354 (Oct.) 1945.

146 Pendergrass, E. P., and Lafferty, J. O. Roentgen Study of the Ankle in Severe Sprains and Dislocations, *Radiology* **45**: 40-44 (July) 1945.

grams Any severe sprain that is to be treated by injection of procaine hydrochloride should also have this type of examination because of the possibilities of an unstable ankle if the external lateral ligaments are torn and not treated by immobilization

McLaughlin¹⁴⁷ describes his method of infiltration of procaine hydrochloride in the treatment of acute sprains Through a skin wheal, a long intramuscular needle being used, all tender areas about the ankle joint are thoroughly infiltrated with 20 cc of a 1 per cent solution of procaine hydrochloride without epinephrine at each site On completion of the injections, the ankle is gently massaged and manipulation of the joint is undertaken The foot is carried into all positions, and if discomfort persists the injection is repeated With satisfactory injection there is immediate relief of pain The author reports that excellent results were observed following primary infiltration of procaine hydrochloride in nine tenths of the 51 cases seen within twenty-four hours after the injury occurred The principal factors which may prevent this method from being successful are delayed injection, inadequate injection and extensive ligamentous damage

Lewin¹⁴⁸ states that in trouble with the ankles and feet the patient is interested in discomfort, disability and deformity The normal and abnormal mechanics and anatomy of the foot are discussed by the author Disturbances of the foot are divided into numerous subdivisions, and various etiologic factors are enumerated The Thomas heel and metatarsal crescent are discussed Lewin attributes a common cause of metatarsalgia to a person sitting with weight resting on the toes and inverting the arch Hallux valgus, bunions and the McBride operation are discussed briefly A brief statement with illustrations is presented on calcaneal spurs, gout, pes cavus, Morton syndrome, sesamoiditis, bursitis, epiphysitis, cyst of the os calcis, gonococcic arthritis and gunshot wounds The Gibney strapping is mentioned and recommended Roentgenologic examination of a sprained ankle with the foot inverted following injection of procaine hydrochloride is advised

Scott¹⁴⁹ expresses the opinion that the essential principles in the treatment of sprained ankles are adequate support and early weight bearing The military boot, laced tightly and padded with felt, makes an ideal dressing for sprained ankles Saddle felt $\frac{3}{8}$ inch (0.96 cm) thick cut in circular pieces $3\frac{1}{2}$ inches (8.8 cm) in diameter and shaped

147 McLaughlin, C. W. Jr. Procaine Infiltration in Treatment of Ankle Sprains, *Mil Surgeon* 97 457-460 (Dec.) 1945

148 Lewin, P. Painful Conditions of the Foot and Ankle Especially Those Due to Injuries, *Proc Interst. Postgrad M A North America* (1944) 12: 1-22-25

149 Scott, W. Sprained Ankles—A New Form of Treatment, *U S A M J* Bull 45 679-684 (Oct.) 1945

off on one side is applied to the inside of the shoe so that the center of the pad corresponds to the center of each malleolus. A $\frac{1}{4}$ inch (0.64 cm) strip is applied to the tongue. The support should be used for at least three weeks to insure healing.

Hipps¹⁰ writes that ligamentous stretching is considered as the basic and major cause of persistent pain in all overused feet, if cases of infectious, degenerative, metabolic and gross trauma are excluded. Most of the pain in pes cavus is due not to stretch of the ligaments but to bruising of the soft tissue under the rigid metatarsal heads, injections of procaine hydrochloride therefore probably would be of no value. A valgus or planus foot condition of such a degree as to be intractable by conservative orthopedic measures is not a suitable condition, since spraining of the supporting ligaments will readily recur on resumption of heavy activity. Ambulation during recovery implies rather moderate activity which does not place enough strain on the ligaments to prevent their healing. The ligaments not only should heal but should hypertrophy and become stronger during the process, a natural physiologic response to the increased demands on the foot. Loss of muscle tone and strength during ambulation is minimal.

The injection treatment of flatfeet and allied conditions is done by the injection of procaine hydrochloride through the sole of the foot into the painful site and the continuation of moderate ambulatory activity while recovery is occurring. The injections, followed by a period of walking, are repeated every third day. Usually after the second injection the patient expresses a desire to return to duty. On discharge from the hospital the patient is given a note requesting two weeks' light duty. Valgus abnormalities were treated the first day by the usual alterations of shoes supplemented with physical therapy, muscle exercises and instructions as to how to stand and walk. Adhesive strapping was discontinued because it limits natural movements of the foot. The author states that treatment by injection as described has reduced the number of hospital days per patient, decreased the number of "survey" cases, increased the number of men returning to duty, decreased the number of recurrences and, surprisingly enough, even decreased by about 50 per cent the number of patients admitted to the hospital for pain in the feet.

[ED. NOTE—Accompanying the reprint was a comment by the author saying that he doubted the value of this method of treatment in private patients of civilian life. This is not in accord with our experience. We have found the injection of procaine hydrochloride of considerable value in the treatment of painful feet due to functional decompensation in civilians.]

VI CONGENITAL DISLOCATION OF THE HIP

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SCHNEIDER¹⁵¹ describes the anatomy of a congenitally dislocated hip in a child of 13 months who died of pneumonia. Retardation of normal development was manifest in delayed appearance of epiphyseal nuclei in the upper and lower extremities. This report constitutes further proof of the etiologic significance of hypoplasia of the joint ends of the bones. Ordinary muscle tone will then have sufficient force to cause a luxation. In the presence of slight hypoplasia the joint may develop normally, but the addition of some exogenous factor may cause dislocation. The earliest date for dislocation is during the third fetal month. The higher incidence of dislocation of the left hip is attributed to factors governing the generally less decided development of left-sided structure.

Heidsieck¹⁵² describes a case of voluntary dislocation in a girl 2 years of age, which was observed accurately by means of the roentgenogram. He states that he has already described 1 other similar case and that Hilgenreimer has reported 2 cases. In this case dislocation occurred almost exclusively at night. Immobilization of the hip at night sufficed to prevent the luxation.

Schrader¹⁵³ reports the case of a 9 month old girl in whom roentgenograms revealed a dislocation of the hip and hypoplasia of the femoral head. Two and one-half years later roentgenograms showed a spontaneous cure, no dislocation was present and the size and shape of the femoral head were almost identical with those of the normal hip.

Perkins¹⁵⁴ summarizes the facts and opinions generally known concerning the subject of congenital dislocation of the hip. The report contains no observations original with the author. This paper is apparently, written for the benefit of the medical student and the general practitioner.

Schwartz¹⁵⁵ demonstrates that with a V-shaped plaster device reduction can be maintained. This type of cast consists of the following parts: casts applied to the legs from the hips downward and including the

151 Schneider, H. Pathogenesis of Congenital Luxation of the Hip—The Point of View of Functional Anatomy. *Ztschr f Orthop* 74 291 1941

152 Heidsieck, E. Dislocation of the Hip. Voluntary Subluxation in Young Children. *Ztschr f Orthop* 74 235 1943

153 Schrader, E. Question of Spontaneous Cure of Congenital Luxation of the Hip. *Ztschr f Orthop* 74 311 1943

154 Perkins, G. Congenital Dislocation of the Hip. *Practitioner* 155 777 (Aug) 1945

155 Schwartz, R. P. V Plaster Splint for Maintaining Reduction of Congenital Dislocation of the Hip. *J Bone & Joint Surg* 27 166-167 (Dec) 1945

with hips maintained in flexion and abduction and knees and ankles flexed to a right angle, and a large V-shaped structure, with the ends of the two arms fastened to the feet and the angle of the V below. The casts with the V extension below them constitute a pentagonal figure. The pelvis is not enclosed in the cast. The casts do not become soiled with urine and feces. Rotation of the femoral heads within the acetabulums is permitted and the child can sit up or lie on his face or back without recurrence of the dislocation.

(To Be Continued)

REVIEW OF UROLOGIC SURGERY

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KIDNEY

Anomaly—Harrison and Botsford¹ review a group of 72 cases of congenital anomalies of the kidney. Twenty-one patients required operative surgical intervention, seven of the operations were for calculi and fourteen were for congenital hydronephrosis. Forty patients were returned to full military duty and 6 to limited duty, and 25 were evacuated to the United States. One patient died. Renal lithiasis, pyelonephritis and hydronephrosis were the conditions superimposed on the renal anomalies. It is thought, as a result of the study of these cases, that when such conditions complicate a renal anomaly the patient is not fit for tropical duty. Patients who require nephrectomy and the majority of those who need plastic procedure for hydronephrosis should, in rare exceptions, be evacuated to the United States. True renal ectopia, horseshoe kidney, other types of fused renal mass and polycystic kidneys are considered as contraindications to overseas service.

Nephroptosis—Burford² states that the commonest and the first symptom of nephroptosis is pain, which the patient experiences after he becomes tired or stands for long periods. The pain may be

1 Harrison, J H., and Botsford, T W. Experiences in the Management of Congenital Anomaly of the Kidney in the Army. *J Urol* 55: 599-622 (April) 1946.

2 Burford C E. Nephroptosis with Coexisting Lesions. *J Urol* 55: 227-230 (March) 1946.

the posterior fossa under the twelfth rib or on either side of the abdomen, and it may extend to the genitalia and urethra. The second commonest symptom and one which accompanies the first is nausea or vomiting. Cases of extreme nephroptosis may occur in obese patients, but the majority of patients are thin, have lost weight and have relaxed abdominal walls. Often the kidney is only a part of a splanchnoptosis which includes a ptosed stomach, a transverse colon in the pelvis and a liver which comes to the level of the crest of the ilium when the patient is standing. If the position of the kidney and ureter causes urinary stasis and hydronephrosis, infection and formation of stones frequently become complications.

A diagnosis of low or movable kidney is not sufficient. In thin patients the kidney may be palpated as low as the pelvic brim, cause no distress and function perfectly in that position. Intervention in such a case is not justifiable. Complete urologic examination with careful interpretation of the findings is necessary before it can be predicted that nephropexy will relieve the patient's symptoms and stop the destructive process in the kidney itself. Use of the proper type of belts and corsets may relieve nephroptosis if they are properly adjusted, but it cures few patients. In many cases Burford prefers to have patients try a nonelastic abdominal girdle for a time, for they will be better pleased with their surgical results after this trial. In nephropexy Kelly's three point stitch in the renal capsule has proved satisfactory. The upper suture is brought out and tied in the intercostal muscles between the eleventh and twelfth ribs. The other two are sutured to the muscles and fascia in the back, under the twelfth rib. Care must be taken not to rotate the kidney out of its normal plane.

Burford's conclusions today are essentially the same as those which he drew eighteen years ago, when he reported his first 48 cases, although much improvement has been made on the plastic procedures at the ureteropelvic juncture. Nephropexy affords permanent relief when ptosed kidneys cause pain and destructive processes. Ureterolysis and plastic procedures on the pelvis are necessary in a large percentage of the cases. It is a safe operation, with a mortality rate of less than 1 per cent. Use of abdominal belts and corsets may give relief but does not cure the condition. Persistent infections in the ptosed kidney may be cured in many cases only by nephropexy which will insure perfect drainage.

Tumors—Wilms's tumor in the great proportion of cases develops in infants and children, and rarely in adults. Twinem³ reports a case of a 75 year old man, who is thought to be the oldest patient on record in whom Wilms's tumor has occurred. The entire ureter and the

3. Twinem, F. P. Wilms' Tumor in Seventy-Five Year Old Male. Report of a Case, *J. Urol.* 55: 246-251 (March) 1946.

ureterovesical orifice were involved with the tumor. The general histologic picture was that of tubules embedded in spindle cells, both elements being neoplastic. The tumor tubules were formed by atypical cells which were frequently more than one layer thick. Cartilage was present. In one section a pale-staining mucoid matrix was noted. Hyperchromatism was distinct in all parts of the tumor. No striated muscle was found.

The treatment of Wilms's tumor is prompt surgical removal, preceded, when reduction in size is important, and followed, in most instances, by irradiation. When the age of the patient and other factors in this case are considered, postoperative roentgen treatment did not seem to be indicated.

Crabtree⁴ states that either benign or malignant tumors of the smooth muscle of the kidney of surgical import are extremely rare. The outstanding peculiarities are distribution beneath the renal capsule, smoothness of texture and a tendency to be associated with cysts. When associated with cysts they appear to lie within the cyst cavity. The size of the tumors, if large, or the presence of the cysts in which they lie may suggest the diagnosis of renal tumor, but grossly they present no characteristic appearance to distinguish them from other tumors or cysts. The tumor tends to show cystic degeneration itself, and, microscopically, cystic tubules can be found. The tumors appear to occur in young adults. They tend to be encapsulated and, if malignant, appear to be curable by nephrectomy. Because of the necessity for pathologic examination to determine whether the tumor is malignant, nephrectomy is the procedure to be employed, at least until the clinical characteristics and their significance are known.

Calculi—Cook and Keating⁵ discuss renal calculi associated with hyperparathyroidism. They state that hyperparathyroidism is an important and relatively frequent cause of renal calculi and that the appreciation of this fact will reduce the number of patients who suffer from recurrent calculi and subsequent serious renal damage.

They made an intensive search in cases at the Mayo Clinic for evidence of hyperparathyroidism, particularly among patients having renal calculi as their chief complaints, and during eighteen months 16 proved instances of hyperparathyroidism were recognized. In 4 of these cases the patients had only the classic disease of the bone and in 14 cases the patients had associated renal calculi.

Even should it ultimately be shown that hyperparathyroidism develops in only 5 per cent of all cases of renal calculi it is a fact that

4 Crabtree, E. G. Leiomyoma of the Kidney Associated with Hyperparathyroidism. *Tr. Am. A. Genito-Urin. Surgeons* 37: 245-255, 1944.

5 Cook, E. N. and Keating, F. R. Jr. Renal Calculi Associated with Hyperparathyroidism. *J. Urol.* 54: 525-530 (Dec.) 1945.

to investigate the possibility in these cases in order to give the patients the advantage of a correct diagnosis. Cool and Keating are of the opinion that in cases of recurrent or multiple calculi the greatest opportunity for establishment of the diagnosis of hyperparathyroidism is afforded. It is generally recognized that approximately 10 per cent of patients who have urinary calculi removed will have a recurrence of the calculi and the authors express the opinion that this percentage can be reduced appreciably if patients who have hyperparathyroidism are carefully excluded. They present a routine for the diagnosis of hyperparathyroidism the diagnostic criteria being hypercalcemia, hypophosphatemia, hypercalciuria and hyperphosphaturia.

Tuberculosis.—Suter⁶ injected into 65 guinea pigs material obtained from sixty-five of two hundred and forty healthy kidneys which remained after nephrectomy was performed for tuberculosis. The results were positive in 25 per cent of the sixty-five tests. In 15 per cent of the 240 cases slight albuminuria was present, and in 10 per cent a few leukocytes were found in the urine. In one half of the 240 cases tuberculosis of the remaining kidney later developed. When results of inoculation of a guinea pig indicated that tuberculosis was present and leukocytes were found in the urine usually tuberculosis developed in the remaining kidney later.

Polycystic Disease.—Young⁷ suggests the use of sclerosing solutions after surgical exposure in treatment of polycystic kidneys. An unusual case of rapid, unilateral renal enlargement occurring in a young girl with polycystic kidneys is presented. Treatment consisted in aspiration of the cysts followed by instillation of 5 per cent solution of sodium morrhuate into large individual cysts after renal exposure. Preoperative intravenous use of indigo carmine is recommended as a necessary precaution to diminish the possibility of injury to the renal pelvis. Theoretic merits of the procedure are discussed.

URETER

Transplantation.—Dodson⁸ states that ureterovesical anastomosis is the most desirable disposition of the ureter when it has been severed accidentally or must be divided near its terminal portion. In resection of a portion of the bladder for malignant disease, when the orifice of the ureter is involved, the ureter may be reimplanted into the bladder, with considerable assurance of permanent preservation of the function of the

6 Suter, F. Die Feststellung der Gesundheit der einen Niere bei der Nierentuberkulose, Schweiz med Wchnschr **76** 125-126 (Feb 16) 1946

7 Young, W. W. Sclerosing Injection of Polycystic Kidney Following Surgical Exposure, J Urol **55** 323-329 (April) 1946

8 Dodson, A. I. Some Improvements in the Technique of Ureterocystostomy, J Urol **55** 225-237 (March) 1946

kidney The same is true when the ureter has been injured or its function impaired by disease sufficiently near the bladder to permit the operation to be performed without tension on the ureter

The ureter can be transplanted successfully either transperitoneally or retroperitoneally In the transperitoneal operation, the peritoneum should be accurately sutured over the ureter and extraperitoneal drainage should be provided to the area of implantation Transperitoneal implantation is the natural procedure when an injury of the ureter is discovered at the time of a pelvic operation When the operation is done exclusively to reimplant the ureter into the bladder, the extraperitoneal approach has several advantages The ureter is more easily exposed and liberated Both the ureter and the portion of the bladder presenting the most desirable location for reimplantation are normally extraperitoneal Retroperitoneal drainage is more easily instituted, and the danger of disastrous results from leakage or infection is less

The site of implantation and the way in which the ureter is made to traverse the vesical wall depend, to some extent, on the length of ureter available and in vesical resection on the amount of bladder that must be removed The implantation should be made into the base of the bladder, near the original ureteral orifice, when possible Angulation at the point of entrance is less likely to occur, and subsequent catheterization if indicated, will be less difficult The ureter should be implanted near the top of the bladder only when it is necessary to prevent tension at the point of union

Mobilizing or straightening the ureter lengthens it and lessens the distance that it must traverse to reach the bladder The additional length of ureter made available by this procedure is considerable This is particularly true when the ureter has become dilated and tortuous because of partial obstruction, which often occurs after disease or fixation at the lower end of the ureter Furthermore, the ureter describes a considerable arc as it curves outward and backward along the surface of the true pelvis This arc can be straightened to a considerable extent without interfering with the function of the ureter The abundant blood supply and the free anastomosis of the ureteral blood vessels make it possible to free the ureter almost completely without danger of necrosis The ureter is endangered only when the loose fibrous coat is stripped away

In Dodson's experience the following operation gave the most satisfactory results An incision is made beginning just above and about 2 inches (5.1 cm) medial to the anterior spine of the ilium and extending downward and inward parallel to Poupart's ligament The peritoneum is separated from the posterior part of the abdominal wall by a dissection from above the brim of the pelvis down to the bladder medially to the spine As the peritoneum is retracted medially, the vessels are exposed and the ureter can be seen as it passes over the

vessels and can be traced along the posterior surface of the peritoneum. The ureter is freed from the peritoneum from well above the iliac vessels downward to the fistula or in ureteral disease, to the bladder. In women, if the ovarian vessels interfere with liberation and exposure of the lower end of the ureter, they may be ligated and divided. The ureter is then divided just above the fistula or the diseased area. The lower stump is ligated or excised according to indications. An incision about an inch (2.5 cm.) long is then made in the posterior wall of the bladder, extending from above downward as near the original ureteral entrance as possible. The incision extends to, but not through, the mucosa which is carefully dissected from the muscles of the bladder for a short distance on both sides of the incision. The mucous membrane of the bladder is then incised at the lower end of the incision, a thin-bladed hemostat is inserted into the bladder, and the end of a catheter, previously passed through the urethra, is grasped and pulled through the incision. The end of the ureter is beveled, and a small soft rubber catheter, which has had the end cut off and two small holes made in the sides near the end, is inserted into the ureter for 3 or 4 inches (7.6 or 10.2 cm.). A suture of 00 plain surgical gut is passed through the tip of the beveled ureter and tied snugly to the catheter. The distal end of this catheter is then sutured to the tip of the bladder catheter, which is withdrawn, the end of the catheter in the ureter being pulled out through the urethra. Fixation sutures are taken through the superficial tissues of the ureter on each side about 1 inch (2.5 cm.) from the beveled tip. Both ends of these sutures are threaded on a small curved needle. The point of the needle is passed through the incision and the vesical wall from within outward. As traction is made on the catheter, the ureter is pulled into the bladder until the area pierced by the sutures enters the incision into the bladder. The sutures are drawn taut and tied on the outside of the bladder as mattress sutures. With the small catheter in the urethra and a large catheter placed suprapubically, complete drainage and absolute immobilization are assured. When the length of the ureter does not permit a submucous implantation, the operation differs only in that the ureter enters the bladder through a short incision directly through the vesical wall.

Cancer—McClelland⁹ reports a primary carcinoma of the ureter treated by excision and anastomosis of the cut ends. The patient, a man aged 62 years, complained of hematuria. An intravenous pyelogram indicated the presence of hydronephrosis on the right side. On cystoscopy, a stricture was found on the lower end of the right ureter. Surgical exploration of the right ureter was performed, the lower

9 McClelland, J. C. Primary Carcinoma of Ureter Treated by Excision and Anastomosis of the Cut Ends, *Tr. Am. A. Genito-Urin. Surgeons* 37: 159-164, 1944.

end of the ureter which contained a new growth was resected and anastomosis was carried out. The pathologic report and diagnosis of the tumor were papillary carcinoma.

O'Connor,¹⁰ in discussing McClelland's paper, objects emphatically to local excision of any tumor of the ureter. During the past twelve years he has operated on 8 patients with primary papillary tumors of the ureter. In all the cases he performed complete nephroureterectomy and resection of a generous portion of the wall of the bladder. No evidence of recurrence of tumor has been found, and all the patients are living and well.

One patient who, about fifteen years ago, underwent an operation in which the kidney and all the ureter except the intramural portion were removed, died three years later of recurrence of the tumor in the vesical wall and intramural portion of the ureter.

Six of O'Connor's patients had undergone partial excision of the ureter and kidney for tumor of the ureter elsewhere. In all these cases recurrence of the tumor occurred in the ureteral stump, and in 2 it occurred in the bladder. Three of these patients had low grade tumors, and, after removal of the ureteral stump and a cufflike portion of the vesical wall, the tumors did not recur. The other 3 patients have died as the result of metastasis of the tumor. These experiences emphasize that the curability of primary tumors of the ureter is directly dependent on complete surgical removal of the entire urinary tree on the involved side at the time of the original diagnosis.

Incontinence—Greene and Ferris,¹¹ in a discussion of urinary incontinence due to bilateral ectopic ureters, state that a correct diagnosis of ectopic ureter will enable the physician to achieve a brilliant cure by the proper surgical procedure, usually heminephrectomy. Female patients, miserable as a result of urinary incontinence, can be restored to perfect continence, and male patients can be relieved of intractable urinary infection by proper diagnosis and surgical treatment. If incontinence persists among female patients after unilateral heminephrectomy, bilateral ureteral ectopia is suggested and further urologic investigation of the opposite kidney, including exploration if necessary, is indicated.

Postcaval Ureter—Lowsley¹² states that postcaval ureter is a rare anomaly. His case was the thirty-fourth to be reported in medical literature. This is an anomaly of the embryonic vascular system rather than of the urinary system, because it results from faulty development of the inferior vena cava. The preureteric vena cava is usually as oriented as other anomalies of the retroperitoneal veins. Of the 34 reported cases

10 O'Connor, V. I. in discussion on McClelland, pp. 187-189.

11 Greene, L. F., and Ferris, D. O. Urinary Incontinence Due to Ectopic Ureters, *Surg., Gynec. & Obst.* 82: 712-716 (June) 1946.

12 Lowsley, O. S. Postcaval Ureter, with Description of a New Operation for Its Correction. *Surg., Gynec. & Obst.* 82: 549-556 (May) 1946.

the condition was discovered in 22 at postmortem examination or laboratory dissection in 11 (including Lowsley's) at operation and only in 1 preoperatively.

Postcaval ureter may be present without producing symptoms. Symptoms when present are those of ureteral obstruction, which may be produced by pressure exerted by the vena cava on the underlying ureter or by kinking or stricture due to the anomalous course of the ureter. Stereoscopic roentgenograms taken with the patient in the anterior, posterior and oblique positions aid in the diagnosis. The roentgenologic appearance is distinctive in the following respects: 1 In an oblique roentgenogram the portion of the ureter dorsal to the vena cava will impinge against the lower lumbar portion of the spinal column, whereas the normally situated ureter will fall away from it. 2 The postcavally placed ureter always is displaced toward, at or even beyond the midline of the body. The ureter winding around the vessel, forms a sickle-shaped curve, with the convexity directed supermedially. Severe damage to the kidney in these cases may necessitate nephrectomy. Otherwise corrective surgical treatment, namely, transference of the ureter from behind the vena cava to its normal position in front of the vessel, is the treatment of choice. Only 4 cases in which corrective surgical treatment was given were reported previous to Lowsley's. In 3 of these, the ureter was divided and the upper portion was anastomosed, in 1, the division and anastomosis were above the ureteropelvic junction.

The operation described aims at the preservation of the intrinsic nerve supply to the ureter and correction of the anomaly. The ureter is severed at its point of entry into the vesical wall, removed from behind the vena cava and placed in normal position, and the end is reimplanted into the vesical wall.

PROSTATE

Cancer—Huggins¹³ discusses prostatic cancer treated by orchiectomy and gives the five year results. His first series was composed of 21 consecutive patients presenting far advanced prostatic cancer as defined by the presence of demonstrable metastatic lesions or local infiltration considerably beyond the prostatic capsule. One patient died of pneumonia eight days after operation and was excluded from the study. Fourteen patients had roentgenographic evidence of osseous metastasis. Irradiation was not employed, and estrogenic substances were not administered until it was obvious that a relapse had occurred.

In 2 cases no obvious benefit was derived from orchiectomy while in the remaining 18 cases alleviation of clinical symptoms occurred for varying periods. In this group of 20 senile men, 2 died as the result of intercurrent disease. Eleven patients (55 per cent) died in the first two

13 Huggins, C. Prostatic Cancer Treated by Orchiectomy. The Five Year Results, J. A. M. A. 131: 576-581 (June 15) 1946.

years after orchiectomy, and 4 patients died in from thirty-six to sixty-three months. The duration of life in the 15 cases in which death occurred was from three and a half to sixty-three months, and the median survival time was sixteen months. The duration of the remission of symptoms in these cases was three and a half to fifty-seven months, and the median duration of improvement was eleven months. The prostate was soft, small and atrophic at postoperative clinical examination in 4 of these 15 cases, while the growth of metastatic lesions was flourishing in bone marrow and lymph gland. Five patients survived more than five years after orchiectomy, 1 man is in good health but has a mass of tumor tissue the size of a hen's egg in the region of the seminal vesicle. No sign of disease can be detected in 4 patients. These 4 patients had evidence of widespread metastasis to bone and an elevated level of serum phosphatase at the time of orchiectomy, in each case, after five years the enzyme levels were within the normal range and the bones showed equivocal or no evidence of metastasis.

The early evidence of clinical improvement after orchiectomy includes the relief of pain, improved appetite, gain in weight, decrease of anemia and decrease of size and sometimes disappearance of the primary tumor and of the metastatic lesions. Occasionally an untreated patient who has prostatic cancer will live for more than five years, however, in such cases the tumor does not regress but grows slowly. An explanation for prolonged survival in those cases must be spontaneous androgen deficiency through accidental physiologic failure of androgen production. It is still impossible to predict the course of the disease after orchiectomy at this time.

Hypertrophy—Schaffhauser¹⁴ reports 313 cases in which prostatectomy was performed. The total mortality rate was 3.8 per cent. The original method of Wildbolz was modified at two points. 1. The prostatic capsule was opened by a bow-shaped incision, according to the method of Kirschner, to avoid damaging the external sphincter. 2. After enucleation of the prostatic adenoma, the prostatic capsule was included in the urethrovesical suture. Spinal anesthesia administered according to the method of McGill proved to be the most satisfactory. The perineal wound closed within fourteen days in 75 per cent of the cases. Hemostasis carried out according to the method reduced bleeding to a minimum. Severe postoperative hemorrhage occurred in only two of three hundred and twenty-seven prostatectomies, including fifteen extracapsular operations for carcinoma of the prostate. In general, Schaffhauser is of the opinion that the importance is attached to the danger of damaging the rectum and the

¹⁴ Schaffhauser, P.-D. F. *Leber, Tumor und Prostata*. Prostatektomie bei Prostatahypertrophie, Helvetica 12 77, 1945.

formation of fistulas, as well as to postoperative incontinence. These complications result from faulty surgical technic and can be prevented by use of a well proved method and by experience. Of all the cases in which operation was performed by Schaffhauser, total incontinence of urine occurred in 1 case. The nonmodified method of Wildbolz was used in that case. In 4 cases rectoperineal fistula developed and healed spontaneously. The formation of rectourethral fistula was never observed. A urethroperineal fistula occurred in 2 cachectic patients, who died shortly after operation. Perineal prostatectomy is superior to transvesical prostatectomy and is worthy of further generalization.

Lazarus¹⁵ states that spontaneous hematuria is a frequent symptom among patients with prostatism and may vary from the presence of a few erythrocytes to the high power field (occult blood) to massive bleeding, which may at times assume alarming proportions. The former occurs much more frequently than does the latter. Bleeding may be due to mucosal ulcerations situated on the opposing surfaces of the lateral lobes, resulting from infection or friction, or it may be due to rupture of small or large varices in the prostatic urethra. In other instances, the bleeding may be due to conditions extrinsic to the prostate which are secondary to obstruction of the vesical neck, such as cystitis, calculi, hydroureter and hydronephrosis.

Cavitary Prostate—Alfonso and Emilio de la Peña¹⁶ state that cavitary or diverticular prostatitis was first referred to by Albarran and Janet. Credit should be given to Luys, of Paris, for having made a thorough study of this condition and for having proposed destruction of cavities by galvanic current applied through the urethroscope. The symptoms of cavitary prostatitis are the same as those of other chronic forms of prostatitis, that is, pus and shreds in the urine, hematuria, frequency of micturition, pain along the urethra and perineum and sexual symptoms. The diagnosis may be made by urethroscopic or urethrogramic examination, the latter being the more accurate of the two methods. Transurethral destruction of cavities has been employed successfully in treatment. In some cases perineal prostatotomy may be indicated. Deep roentgen therapy has resulted in definite cure in a small number of their cases.

BLADDER

Tumor—Rose¹⁷ reports his results of treatment of carcinoma of the bladder with open roentgen therapy in more than 40 cases. The basic

15 Lazarus, J. A. The Significance of Spontaneous Hematuria Associated with Hypertrophy of the Prostate, *J Urol* 54 531-538 (Dec.) 1945

16 de la Peña, A., and de la Peña, E. Diverticular or Cavitary Chronic Prostatitis, *J Urol* 55 273-277 (March) 1946

17 Rose, D. K. Open X-Ray Therapy in Carcinoma of the Bladder, *J Urol* 55 267-272 (March) 1946

principle has been, and still is, that vesical carcinoma of the invasive type is sufficiently similar to carcinoma of the skin that if direct exposure to roentgen rays could be applied as successfully to the bladder as they are to the skin certain desperate carcinomas of the bladder might be cured. The critical surgical points are removal of all redundant tissue and holding of the cancer-bearing area of the vesical wall taut and flat when treatment is given. It is necessary that the basement area of the carcinoma be presented as a flat surface to the target so that the roentgen rays can be distributed evenly over and through it.

A most important technical development that has improved Roentgen statistics in the last few years is the removal of redundant tissue, bloody urine and blood clots from the surface of the tumor, so that the basement area of the tumor and its stretched adjacent vesical wall receive full benefit of the irradiation.

This form of treatment is used for invasive tumors only of the most desperate type. When the tumor involves the base or the side wall direct exposure can be given, but when the vesical outlet is invaded results are not satisfactory by this method. Even though the carcinoma is large or multiple and covers the floor and a lateral wall results may be satisfactory.

In the early experimental stages of this work Rose used the treatment only in cases of extreme dysuria and toxicity caused by large infiltrative carcinoma of the bladder, in which definite evidence of metastasis was present. The relief gained by reduction of the dysuria warranted operation. In 3 such cases, although the patients died as the result of metastasis later, the bladder showed no malignant cells. After some time roentgen treatment was given in cases in which no evidence of metastasis was present and in which the choice of treatment was between cystectomy, implantation of radon seeds, closed roentgen therapy or open roentgen therapy. Later, invasive tumors not so large, yet which Rose considered of a desperate type, that is, those involving the ureteral orifice the size of possibly 2 to 3 inches (5.1 or 7.6 cm.) or more across, were treated by this method. The results warranted further effort.

At first Rose used approximately 1,800 r twice. No difficulties were encountered in exposing the tumor at the second operation. He has by this method that his best early results were obtained. He has given approximately 3,300 r in one treatment and anticipates in the near future "near term" favorable results in about 25 per cent of cases. The expectancy of cure of the vesical carcinoma but death of the patient if metastasis is somewhat higher.

Jewett and Strong¹⁸ discuss the relationship of the depth of penetration of the wall of the bladder by infiltrating carcinoma and the

18 Jewett H. J. and Strong G. H. Infiltrative Carcinoma of the Bladder. Relation of Depth of Penetration of the Bladder Wall to the Extent of Extension and Metastasis. *J. Urol.* 55: 34-372 (1946) 12.

to the incidence of local extension and metastases. They made an exhaustive survey of necropsy material. They collected 127 cases of infiltrating tumor of the bladder in which necropsy had been performed but were obliged to eliminate 20 cases because the pathologic material was not suitable for this particular study. They then undertook to determine in these 107 cases the relation of depth of penetration of the bladder wall to the incidence of (1) metastasis, (2) lymphatic capillary invasion (incipient metastasis) and (3) perivesical fixation.

First they separated the cases into three groups according to depth of penetration of the vesical wall. Group A comprised those in which tumor cells were confined to the submucosa. Group B consisted of those in which infiltration had extended into but not through the muscularis. Group C included all cases in which tumor cells had extended completely through the muscle coat. They then determined in each group the number of cases in which regional or distant metastasis had occurred,

Potential Curability of Infiltrating Carcinoma of the Bladder

	Group A (Submucosal Infiltration)	Group B (Muscular Infiltration)	Group C (Perivesical Infiltration)
Cases	3	15	89
Metastasis	0	1	52
Perivesical lymph only	0	0	6
Perivesical fixation	0	0	8
Potentially curable	100%	86.6%	26%

the number in which perivesical lymphatic or vascular invasion only had occurred and the number in which perivesical fixation of the mass was present. In each group the percentage of cases without these evidences of tumor spread gives them their figure for potential curability. The number of cases in groups A and B is small probably because at necropsy cases for the most part represent late stages of the disease. By the term "potential curability" they mean to imply only a theoretic possibility based on the exclusion of all gross and microscopic evidence of tumor spread, actual or incipient, beyond the confines of the vesical wall.

Of the 89 cases comprising group C, regional or distant metastasis was present in 52. The regional lymph nodes were the site of metastasis in 33 instances, the liver in 26, the lungs in 18 and the vertebral column, including the sacrum and pelvis, in 11. Other tissue was involved twenty times but in only 7.7 per cent of the cases without involvement of lymph nodes, liver, lungs or bones. In 36.5 per cent of the cases in which evidence of metastasis was found, the regional lymph nodes were not involved.

In 26 per cent of the 89 cases in which tumor cells were present in the perivesical tissue, metastasis, lymphatic invasion and fixation had not

occurred. It, therefore, is evident that infiltration of the perivesical tissue and invasion of lymphatic vessels are not necessarily simultaneous. In the 19 cases in which surgical deaths occurred, metastasis was present in only 26 per cent, whereas in the group of late cases metastasis was present in 67 per cent. Lymphatic invasion and fixation to neighboring structures, however, brought the theoretic incurability in the first group to 63 per cent and in the second to 78.5 per cent, which is extremely high when compared with the low figure of 13 per cent for group B.

Scholl¹⁹ reports a case of xanthoma and carcinoma in a diverticulum of the urinary bladder. A man aged 59 years had occasional attacks of urinary infection and hematuria. Cystoscopy revealed no urethral obstruction or prostatic hypertrophy. A grayish white, tumor-like mass in the bladder extended into a fairly large diverticular opening. Blood could be seen coming from the diverticular opening. At operation a tumor mass could be felt in the diverticulum. The sac and a segment of the vesical wall containing the grayish white area were resected. On opening the diverticulum, two large papillary carcinomas were found. The grayish plaque which extended from the bladder up into the sac was a xanthoma. The other two separate tumors were papillary carcinomas of a high degree of malignancy. Healing progressed normally. A year later no evidence of recurrence was found.

O'Connor,²⁰ in discussing Scholl's paper on diverticulum of the bladder, emphasized one fact. The tendency on the part of urologists who perform transurethral prostatic resection in all cases to disregard the importance of diverticula of the bladder as a symptom-producing factor has been increasing. This disregard is becoming widespread and has been indulged in by many competent urologists, who advise leaving the diverticula and merely resecting the vesical neck. That this is good judgment in the case of small diverticula which drain freely is evident but, if the diverticula are large and do not drain freely, one should be sure that the diverticulum is not the seat of stone or tumor.

Barringer,²¹ in discussing Scholl's paper, reported 2 somewhat similar cases. One patient had had infection from the time that he was a college student until he was about 60 years old. This infection was caused by an enormous diverticulum, which extended to the diaphragm and could not possibly be removed. At that time multiple small infiltrating carcinomas were present all over the bladder. Barringer performed suprapubic drainage at one time late in the course of the disease. The patient died. The second patient had complete retention of urine. Cystoscopic examination was made, and it was found that he had an inflamed

19 Scholl, A. J. Xanthoma and Carcinoma in a Diverticulum of the Urinary Bladder, *Tr. Am. A. Genito-Urin. Surgeons* 37: 67-71, 1944.

20 O'Connor, V. J. in discussion on Scholl,¹⁹ p. 84.

21 Barringer, B. S., in discussion on Scholl,¹⁹ pp. 83-89.

otherwise normal bladder. Continuous catheterization was necessary for twenty years after this. Suprapubic drainage was then performed. At that time precisely the same condition was found as in the first case—"multiple tumors, small, infiltrating plaques all over the bladder." Obviously, in some way the infection must have been a contributory cause to the tumor.

Shivers²² presents 2 cases of advanced infiltrative carcinoma of the base of the bladder in which bilateral subcapsular orchiectomy was performed. Striking alleviation of subjective symptoms and apparent retardation in the rate of the growth of the tumor occurred postoperatively. He suggests that orchiectomy may prove a valuable adjunct to other well established procedures.

Malacoplakia—Cristol and Broders²³ report 2 interesting cases of malacoplakia of the bladder. The name "malacoplakia" (from the Greek word *malakos*, meaning "soft") was given to this pathologic change by von Hansemann in 1903. This disease is not limited to the bladder, it may also affect the ureters, renal pelves and renal parenchyma. Its importance rests in its recognition and differentiation from malignant change. The cause is unknown. Von Hansemann found clumps of bacteria resembling *Escherichia coli* in several of the lesions that he examined. Grossly or cystoscopically the characteristic lesions appear as plaques, which vary in number, size and distribution. There may be two or three, or there may be several hundred. In size they vary from nodules as large as miliary tubercles to confluent lesions measuring several centimeters in diameter. The plaques have a variable distribution and most characteristically are scattered over the entire mucous membrane. They appear as grayish yellow or yellow-brown, flat-surfaced areas. The majority of the patients are women more than 30 years of age who have had frequent bouts of cystitis. Urinary frequency and gross hematuria are the most prominent symptoms.

The cases of malacoplakia so far reported are too few for the treatment to be standardized. The authors agree with others in reporting fairly good results following fulguration. Removal of a source of infection, such as a diseased kidney and ureter in 1 case, was followed by the disappearance of the lesions with their attendant symptoms. Other authors have used local applications of potassium iodide and autogenous vaccines. Occasionally, excision of the lesions has been carried out when they were considered accessible.

22 Shivers, C. H. deT. Bilateral Orchiectomy in Advanced or Recurring Carcinoma of the Bladder with Severe Subjective Symptoms. A Preliminary Report. *J. Urol.* 54: 539-546 (Dec.) 1945.

23 Cristol, D. S., and Broders, A. C. Malacoplakia of the Bladder—Report of Two Interesting Cases, *J. Urol.* 55: 260-266 (March) 1946.

Rupture—Brooks²⁴ reports a case of traumatic rupture of urinary bladder in an infant 3½ months old, who recovered. Ashurst reports an analysis of 110 cases, in which the mortality rate was 42 per cent. Besley reported 23 cases at Cook County Hospital, in which there were 18 deaths and 5 recoveries, a mortality rate of 78 per cent. In Campbell's series of 55 cases the mortality was 35, a rate of 63 per cent. Negley reports 215 cases, with a mortality rate varying from 11 per cent, in those in which operation was performed within the first twelve hours up to 52.3 per cent, in those in which operation was performed after twelve hours.

After checking the analysis of nearly 1,000 cases, Brooks considered his case unique in that the patient was the youngest to recover from ruptured bladder. He found records of a patient 2½ years old reported by Huff and of 3 patients 3 years old reported by other authors. In 1918, an article by Angevine reported a case of fractured pelvis with rupture of the bladder in an infant less than 2 years old who recovered.

The mortality rate is much higher than for rupture of a peptic ulcer if operation is performed within twelve hours, but after twelve hours the rate rises much more rapidly in cases of ulcer. The seriousness of ruptured urinary bladder has not been stressed in textbooks. The average physician does not realize the seriousness of the condition. The etiologic factor in rupture of bladder may be of the following types: trauma when the bladder is more or less distended with urine, an accident with a full bladder, penetrating wounds, such as a gunshot stab and shrapnel, fractured pelvis, or any violent blow or fall. Predisposing factors are intoxication, hypertrophied prostate, pregnancy, stricture of urethra or any other condition that may interfere with urination. Symptoms of intraperitoneal rupture of the urinary bladder are similar to those of rupture of intestines or of any hollow viscus such as the stomach, within the abdomen. The most important point in the diagnosis is a history of not having voided since the accident. The point led to the diagnosis in Brooks' case. It is unwise to wait long for a patient to void, because if there is much shock there will be little urinary secretion while the patient is in shock. Every hour lost before operation counts in the mortality rate. Diagnostic points are (1) a history of accident, (2) inability of the patient to void and (3) pain in the abdomen and rigidity. Diagnostic aids are (1) roentgenologic examination to determine whether the pelvis is fractured, (2) injection of sterile opaque solution into the bladder and (3) injection of air into the bladder and roentgenologic examination of the patient in the upright position.

²⁴ Brooks, R. E. Traumatic Rupture of Urinary Bladder in an Infant and One Half Months Old with Recovery. *J. Urol.* 55: 363-365 (April) 1916.

The patient, aged 3 months, had been in an automobile wreck the previous night (about eighteen hours earlier) and had not voided since. The child was in shock and was crying as if in severe pain. The abdomen was rigid and distended. Catheterization yielded no urine. The roentgenogram did not reveal fracture of the pelvis or any other bones but showed a tremendous amount of gas in the intestinal tract. Brooks injected 20 cc of diodrast into the bladder. The solution was immediately disseminated throughout the abdominal cavity.

The diagnosis of ruptured bladder was made, and transfusion of 150 cc of citrated blood in the jugular vein was given at once. The patient was prepared for operation, which was performed twenty hours after the accident.

An incision was made low in the midline. The peritoneum was opened and much urine aspirated from the abdominal cavity. There was a rent 5 cm long in the dome of the bladder. Brooks closed the peritoneum and placed a no. 16 Foley catheter in the bladder and a small piece of rubber drain in the space of Retzius. A small catheter was placed in the urethra for drainage. The patient began taking nourishment the next day. The tube and catheter were removed on the sixth day, and the patient began voiding within a few hours.

Foreign Body—Bors and Bowie²⁵ discuss the migration of foreign bodies and report a case of migration of a shell fragment into the bladder. A 23 year old white soldier was wounded by hand grenade. The shell fragment hit him in the right thigh, causing a compound comminuted fracture of the right femur in the middle third. Stereoscopic roentgenograms revealed a metallic foreign body in the pelvis, well outside the outline of the bladder. Later the patient had slight hematuria. About a week later he noticed slight burning on micturition, terminal dysuria and frequency. Symptoms increased but did not become severe. A splinter could be felt just under the skin left of the radix penis. Roentgenologic examination revealed a metallic foreign body surrounded by several concentric layers of calcium in the region of the bladder. This diagnosis of calculus in the bladder was confirmed by cystoscopy. The calculus containing the metal splinter was removed by suprapubic approach. Spinal anesthesia was used.

The important feature in migration of a foreign body is the free interval between injury and the first onset of urinary symptoms which indicate involvement of the bladder. It is likely that the end of the free interval marks the onset of penetration. The interval in this case was about five months. This corresponds to the reports on the migration

25 Bors, E, and Bowie, C. F. Migration of Foreign Bodies with Report of Case of Migration of a Shell Fragment into the Bladder, *J Urol* 55 358-362 (April) 1946

of pegs or pins used for the repair of fractures of the hip joint, whereas in a case of bullet penetration the interval was five years

SCROTUM AND TESTICLE

Trauma—Swersie²⁶ presents 2 cases of uniform simultaneous swelling of the testicle and epididymis on the left side following blast injury. It is suggested that this type of injury may produce tension about the external inguinal ring, which in turn impedes circulatory return from the scrotum. This condition probably is diagnosed epididymitis or epididymo-orchitis without due consideration of the cause. The term "blast scrotum" would seem more appropriate.

Tumors—Lowry, Beard, Hewit and Barner²⁷ give an analysis of 100 cases of tumor of the testicle. They state that this is a disease of early adult life and that many cases of the condition have been seen in the military service. Treatment in 100 cases of teratoma of the testicle was in general by the same method, that is, by orchiectomy followed by deep roentgen therapy. It is believed that this group of cases, with proper subsequent follow-up, will serve to test the efficacy of this method of treatment. Tumors of the testicle comprise approximately 4 per cent of all malignant lesions of the genitourinary system in civilian hospitals. In an Army general hospital, where a great majority of the patients are between 20 and 40 years of age, the disease is seen with greater frequency. In the first 27,000 admissions to this Army general hospital 100 cases were observed. Teratoma of the testicle represented approximately 70 per cent of all neoplasms of the genitourinary system and 7.86 per cent of all malignant tumors.

For many years there has been diversified opinion regarding the classification of teratoma of the testicle. The classification employed by the majority of urologists is that suggested by Ewing, based on the microscopic appearance or cell type of the tumor. Malignant tumors of the testicle are considered to arise from a cell which is capable of producing tissue resembling that arising from any or all three germinal layers.

Since adult teratomas are derived from a cell capable of producing any tissue originating from the three germinal layers, they contain adult rudimentary organs. Cartilage, muscle tissue, glandular tissue, hair follicles, fibrous tissue and bone are found in that order of frequency. These tumors must always be considered malignant even though malignant tissue is not found after careful search.

26 Swersie, A. K. Unilateral Scrotal Swelling Following Blast Injury—A Syndrome, *J Urol* 55:292-294 (March) 1946.

27 Lowry, E. C., Beard, D. E., Hewit, L. W., and Barner, J. L. Tumors of the Testicle. Analysis of One Hundred Cases, a Preliminary Report, *J Urol* 55:373-384 (April) 1946.

Mixed type teratomas are similar to adult teratomas but contain malignant tissue in the form of embryonal carcinoma, seminoma or adenocarcinoma. By far the commonest testicular malignant lesion is embryonal carcinoma. Microscopically the tumor consists of a uniform large, round, polyhedral cell with an abundant clear cytoplasm. Seminomas are usually of the single cell type but were noted in mixed tumors in this series of cases on two occasions. Microscopically the tumor is little different from embryonal carcinoma. Adenocarcinomas are composed of a homogeneous cellular structure having a tendency toward formation of alveoli. In some of these tumors of apparently a single cell type careful search of many sections will sometimes reveal adult elements, but in many instances no such adult tissue can be found.

The chief complaint in 86 per cent of the cases reported herein was "painless swelling of the testicle," which in most cases was accompanied with other symptoms referable thereto, such as heaviness in the scrotum and the mechanical interference of the enlarged testicle during exercise. Six patients in this series complained of pain in the affected testicle, the pain varying from dull ache to sharp incapacitating pain. These cases were all of the type with a history of sudden enlargement of the testicle within a few days prior to the onset of pain. The diagnosis of teratoma of the testicle can, with few exceptions, be made with accuracy by physical examination. The enlarged testicle invariably maintains the configuration of the normal testis, no matter what size it attains. The tumor is usually of uniform consistency and is firm and rubbery. The affected organ is stony hard, chiefly in the adult type of tumor. The successful management of teratoma of the testicle depends mainly on early diagnosis. The average interval in these cases between the first symptoms noticed by the patient and operation was ten months.

Malignant lesion of the testicle may be confused with epididymitis, orchitis, hydrocele, hematocele, torsion of the cord, tuberculosis and syphilis of the testicle. Acute epididymitis, torsion of the cord, hematocele and orchitis are associated with severe pain and testicular tenderness and occasionally with fever and leukocytosis. Tuberculosis is associated with pyuria and induration of the prostate and vesicles. Tuberculosis is practically never primary in the testicle, and a focus can usually be found in the lung or elsewhere in the urinary tract. Hydrocele is a fluctuant tumor which transilluminates light except in the chronic thick wall type. Hydrocele, both acute and long standing, is an elongated tumor, and almost never is the normal contour of the testicle preserved. Syphilis of the testicle produces a hard, irregular, painless tumor, which, associated with a history of a primary lesion and a positive serologic reaction of the blood, leads to the correct diagnosis. Hematocele is painful in the acute phase, and a history of trauma usually can be elicited. The quantitative analysis of the urine for prolan A has

proved to be a valuable adjunct in the diagnosis of these tumors in some clinics. Not only is the diagnosis made, but the type of tumor is said to be predicted with a fair degree of accuracy.

Metastasis from teratoma of the testicle is prone to occur early and is, with rare exceptions, by way of the lymphatic vessels. The lymphatic drainage of the testis is almost entirely to the periaortic nodes. The main lymphatic channels accompany the spermatic vessels from the testicle through the cord as far as the level where the vessels cross the ureter, and from here they lead directly to the periaortic nodes from the level of the bifurcation of the aorta to the celiac axis at a region near the renal pedicles. In this series of cases, metastasis was found to have occurred in 32 cases, invariably by way of the lymphatic vessels with the exception of 1 case, in which the patient died when the vena cava was invaded by direct extension of metastatic lesions along its course. The patient died of pulmonary embolus.

In this group of 100 cases treatment in general was by the same method, that is, after the method described by Dodson, in which the testicle was removed after ligation of the spermatic cord at the level of the internal inguinal ring. An incision is made parallel to the inguinal canal on the affected side, 6 to 10 cm. in length, depending on the size of the affected testicle. The incision is not extended into the scrotum and the external oblique muscle is divided in the line of its fibers for an equal distance. The spermatic cord thus exposed is ligated at the level of the internal inguinal ring before the testicle is disturbed. The testicle is then, by gentle traction, delivered into the wound and removed. In this series of cases a more radical orchiectomy, with dissection of the lymph glands on the affected side, was not performed. Since in many cases metastasis to the opposite side had occurred, lymphatic dissection on the affected side is not considered a curative procedure.

Roentgen therapy is generally started as soon as the patient can be comfortably transported to that department (as a rule, three to five days after operation).

The results of the treatment in this series of cases to date have been somewhat discouraging. Twenty-four patients on admission had definitely demonstrable evidence of metastasis, and in 2 other cases metastasis occurred while the patients were in the hospital. Subsequent examination reveals that 12 additional patients now have demonstrable evidence of metastasis. When roentgen therapy was administered before metastasis had occurred, in only a few cases did the size diminish appreciably or the metastatic mass disappear. When an initial response was obtained the growth subsequently recurred. In several cases definite advancement of the disease was noted during the course of the treatment. Fourteen of the patients are now dead, an additional 8 are bedridden and are dying from the disease. Sixty-eight of the 100 patients

are now living and well and are at the time of this report without evidence of metastasis. The length of time that has elapsed since operation in these cases varies from a few weeks to three years. All these patients were treated as previously indicated by orchiectomy and roentgen therapy.

Barringer²⁸ discusses the prognosis in teratoma testis. Early simple orchiectomy is necessary to provide a pathologic diagnosis. With the exception of the rare cases in which an extremely high output of prolan B indicates the presence of chorioma, there is absolutely no sure method of making a preoperative diagnosis. It does not seem to matter, so far as the final outcome is concerned, whether the testicle is removed immediately or some weeks after irradiation.

Barringer has reviewed the pathologic material obtained at operation. There were 69 cases in all. Of these there were 55 cases of seminoma (80 per cent) and 12 cases of adenocarcinoma (17 per cent). In 31 of the 55 cases of seminoma (56 per cent) the patients were well for five years or more, and in 9 of these 31 (29 per cent) metastasis had occurred. Of the 12 patients who had adenocarcinoma 10 (83 per cent) were well for five years. Four of the ten adenocarcinomas (40 per cent) had metastasized. These figures emphasize that surprisingly few patients with metastasizing seminoma survive, whereas a relatively high percentage with metastasizing adenocarcinoma survive for more than five years.

The lymphatic vessels of the cord are not often invaded by the testicular tumor. If metastasis occurs by way of the lymph channels, generally the channels do not become involved but the glands beyond do. If there is direct invasion of the lymph channels, this is shown by the pathologic examination of the cord in the removed testicle or by teratomatous growth at the site of the stump of the cord occurring sometimes after the operation. If the lymphatic vessels of the cord are involved, the prognosis is much graver. The most important parts of the physical examination are examination of the abdomen for masses and of the left supraclavicular region for involvement of a single node. A roentgenogram of the thorax may reveal evidence of metastasis to the lung. One examination rarely done (and it is strange that trained urologists should neglect this) is rectal examination. In a few cases, perhaps 1 per cent, the periprostatic lymphatic vessels are the site of massive metastasis. If such metastasis is present, the prognosis is naturally graver.

The site of involvement of regional nodes in 37 cases in which necropsy was performed was as follows: inguinal, 4 cases (10.8 per

28 Barringer, B. S. Prognosis in Teratoma Testis. *Tr. Am. A. Genito-Urin. Surgeons* 37: 197-206, 1944.

cent), pelvic and iliac, 14 cases (37.9 per cent), lumbar, 20 cases (54.16 per cent), celiac, 21 cases (56.87 per cent), mesenteric, 7 cases (18.95 per cent), mediastinal, 18 cases (48.7 per cent), bronchial, 13 cases (35.2 per cent), and cervical, 13 cases (35.2 per cent)

A tumor of the testicle rarely metastasizes to the inguinal node unless it has perforated the tunica vaginalis or capsule of the testicle. In several cases enlargement of these nodes appeared after operation. Barringer states the belief that involvement of the inguinal nodes may be the result of cutting into the teratoma with the resultant implanting of tumor cells in the operative wound and a secondary involvement of the inguinal glands. The skeleton was involved in 4 cases (10.8 per cent).

Appendical Torsion—Vermeulen and Hagerty²⁹ report 2 cases of torsion of the appendix testis (hydatid of Morgagni). They state that unless it is realized that the severity of symptoms produced by torsion of this minute structure may be out of all proportion to the size of the appendix testis, it may easily be mistaken for other intrascrotal disease, such as acute epididymitis, acute orchitis or torsion of the spermatic cord. In other instances a diagnostic mistake may be made because the initial symptoms sometimes focus attention on the lower part of the abdomen and little is present to indicate that the lesion is inside the scrotum. In general, however, the symptoms are those of torsion of the testis.

Vermeulen and Hagerty made a study of the anatomy of the appendix testis and state that grossly it is a small ovoid or flattened tab of pale gelatinous tissue, varying from 1 mm to 1.0 cm in diameter. It is attached to the tunica albuginea by a short pedicle. In at least half of the specimens examined, the pedicle was sufficiently long and narrow so that it could have undergone torsion.

Microscopically the appendix testis is made up of loosely arranged connective tissue moderately rich in blood vessels. In the connective tissue of some specimens were seen spaces of varying size apparently lined with endothelium and frequently containing precipitated albuminous material. These structures had more the appearance of lymphatic channels than of the remnants of epithelium-lined tubules. All the appendix testes were covered by tall columnar epithelium, which was sometimes ciliated. This epithelium became continuous with the flat columnar epithelium of the tunica albuginea. The epithelial covering of the appendix testis and the lining of the epithelial inclusions closely resembled the lining of the distal end of the fallopian tube of the female. This would be expected, because the appendix testis is derived from the cranial end of the müllerian duct, which in the female forms the fimbriated end of the fallopian tube.

²⁹ Vermeulen C. W., and Hagerty, C. S. Torsion of the Appendix Testis (Hydatid of Morgagni). Report of Two Cases with a Study of the Microscopic Anatomy. *J. Urol.* 54: 459-465 (Nov.) 1945.

Orchitis—Burhans³⁰ discusses the inflammation of the testicle in mumps and states that it is not primarily orchitis but an acute hydrocele around the testicle, which causes strangulation of the testicle, in contradistinction to a slow-forming hydrocele. This acute process causes strangulation, acute inflammatory edema and ultimate fibrosis and atrophy of the testes. If a small scrotal incision is made during the acute orchitis, acute hydrocele is encountered. The fluid in the tunica vaginalis is under extreme pressure and has a viscid yellowish color. If drainage is accomplished at this time, no further therapeutic measure is needed and the temperature curve simulates that in crisis of pneumonia. If drainage is delayed until acute swelling and fever have developed, the acute tension and pressure of the hydrocele are not present and the testicle is blackish in appearance. On incision of the capsule or tunica propria and tunica albuginea, the testicular tissue presents an appearance of bulbous edema and inflammation. Burhans suggests incision and drainage of the acute hydrocele in early cases, with removal of the drain in forty-eight hours. In late cases incision of the tunica vaginalis and incision and drainage of the tunica propria and tunica albuginea should be employed. General anesthesia induced with pentothal sodium is the anesthetic of choice.

URETHRA

Lintgen and Herbut,³¹ in a clinicopathologic study, sectioned and studied 100 female urethras and the urethras of 16 newly born full term or premature male infants. Measurements were taken of the prostatic urethras of 40 men. None of the female urethras studied showed evidence of obstruction. Glands were found in every case in the anterior part of the female urethra and in 65 per cent of the posterior part of the female urethras. Seventy-six of the 100 female urethras showed inflammatory reaction histologically. The cause or causes of the inflammation were not apparent. Posterior urethral glands, previous catheterization or cervical inflammation did not appear to be a contributing factor.

Diverticula—Herman and Greene³² state that despite attention which has been paid to urethral diverticulum in the female the origin of the condition remains obscure. The average age of patients is about 40 years. The majority are married and have borne one child or more. The condition is relatively commoner among Negro women, probably owing to the greater frequency and neglect of urethral infections and

30 Burhans, R. A. Treatment of Orchitis of Mumps, *J Urol* 54 547-548 (Dec.) 1945

31 Lintgen, C, and Herbut, P. A. A Clinicopathological Study of One Hundred Female Urethras, *J Urol* 55 298-305 (March) 1946

32 Herman, L, and Greene, L. B. Diverticulum of the Female Urethra, *Tr Am A Genito-Urin Surgeons* 37 297-311, 1944

poor obstetric care. Calculi occur in association with diverticula in 17 per cent of cases, the majority developing in situ from urinary crystals. Ammonium phosphate is the commonest constituent of such stones. Migratory urinary calculi rarely find their way into diverticula and grow by accretions. Like foreign bodies they may become impacted behind urethral strictures, causing periurethral abscesses, the resulting cavities being classified as diverticula. Among the 63 cases in this report, 4 were complicated by two or more stones and 7 by single stones. A most unusual case in which thirteen ammonium phosphate stones were fitted together to form a mass the size of an orange is described.

Urethral diverticula in the female may be silent or give rise to most insignificant symptoms. This is true especially when the sac is small and uncomplicated, provided with a large opening and situated beneath the anterior third of the urethra. On the other hand, the symptoms may be severe. In most cases mild vesical irritation with dysuria, frequency and urgency of urination results. Obstructive symptoms including urinary difficulty, acute and chronic retention, dribbling and true or paradoxical incontinence are rather rare and more likely to occur when the sac is large and springs from the deep segment of the urethra; they are rarely due to associated urethral stricturing. The symptom directly referable to uncomplicated diverticulum is a painless lump in the vagina, which the patient may have discovered accidentally and in rare instances, may have noticed that it increased in size during urination and reduced in size thereafter or that it could be emptied by pressure. The inflammation of the sac is likely to be associated with pain in the urethra, pain on urination and during coitus, soreness in the vagina on sitting or walking and, in some instances, purulent urethral discharge. Spontaneous urethral hemorrhages may originate from ulceration or a complicating neoplasm originating from the sac wall. Referred symptoms comprise rectal irritation and pain referred to the pelvis, lumbar region, back and along the course of either ureter.

Diverticula of the urethra are often overlooked either (1) because suggestive symptoms and signs are wanting, (2) because certain complicating lesions such as urethritis give rise to many of the symptoms commonly occurring in association with diverticula or (3) because examination fails to disclose the condition. The diagnosis is not difficult enough in cases in which a suburethral mass is found that empties on pressure with the discharge from the urethra of mucoid, purulent or bloody fluid. However, the sac may be collapsed at the time of examination and therefore impalpable or, if distended may fail to be

because the orifice is occluded or the sac filled with a neoplasm or thick, mucopurulent secretion

The majority of diverticula are about the size of an English walnut and attached to the floor of the middle third of the urethra. Their size varies from that of a pea to that of an orange and may empty into the urethra at any level. The anterior third of the canal is rarely involved, while comparatively few diverticula empty into the proximal segment. In the latter event the sac may burrow beneath the sphincter and trigonal areas, rendering operation more serious and difficult. In 1 case, the sac encircled the urethra. Acute inflammation of the sac and surrounding tissues may lead to closure of the orifice and preclude instrumental studies, in which event the lesion may be diagnosed as simple abscess and treated by incision and drainage.

Roentgenography, urethroscopy and urethrography are employed not only to assist in and to confirm diagnosis of diverticulum but to determine the size and location of the orifice or orifices, the size, location and form of the sac, whether it is unilocular or multilocular and whether it is smooth walled or with filling defects suggestive of neoplasm.

Satisfactory visualization of the orifice of a diverticulum, which may be small and, whatever the size, obscured by redundant folds of mucous membrane, is best accomplished by employment of a direct vision water-dilating urethroscope, which permits inspection of the entire circumference of the distended urethra at all levels. Herman and Greene find oblique, indirect and right angle telescopes unsatisfactory for this purpose. The orifice is usually round and smooth and often situated slightly lateral to the midline, but it may be linear and irregular. In some cases there are two or more small openings, the involved area presenting a cribriform appearance. Roentgenologic visualization of a soft shadowgraph catheter or opaque medium introduced into the cavity is a useful diagnostic measure but less so than cystourethrography.

With few exceptions diverticula should be removed through the vagina. This comprises (1) introduction of a Foley catheter, (2) exposure of sac through an adequate incision in the vaginal wall, (3) mobilization of the sac to the area of its urethral attachment, (4) excision of the sac close to the urethra, (5) careful closure of the linear defect in the urethral floor, care being taken to include in the sutures a narrow margin of the urethral wall on either side, the defect being closed in the long axis of the urethra (inversion of the tissue is to be avoided), (6) if possible, the bringing together of the separated layers of vaginal fascia independent of the vaginal mucosa as a means of providing maximum support, and (7) the trimming of one vaginal flap so that when brought together the suture lines will not be superimposed.

hypertension The possibility of cure in a given case is influenced to a great extent by the duration of the hypertension, inasmuch as in chronic hypertension irreversible vascular changes may have occurred in the opposite kidney which will prevent a return of the blood pressure to normal

There is accumulating considerable clinical evidence which will aid in evaluation of nephrectomy for the treatment of hypertension associated with various unilateral lesions of the genitourinary tract Unilateral atrophic pyelonephritis apparently offers the most promise of cure by that means Patients who have tuberculosis, renal neoplasm and renal calculi with infection also may be benefited by this operation

A careful evaluation of changes in blood pressure following nephrectomy is essential No patient should be considered cured until he has been followed up for at least a year, since postoperative rest in bed and removal of toxic irritants contained within such diseased kidneys can cause a temporary fall in blood pressure

URINARY INFECTION

Proteus infections in general and those of the urinary system in particular are discussed by Stul,³⁷ based on his experience with treatment in 22 cases *Proteus* infection of the urinary system is rare The pathogenesis, which corresponds to that of colibacillary infection, is not discussed Mixed infections of *Escherichia coli* and the coccal group occur at least as commonly as those caused solely by *Proteus vulgaris* Cystitis and pyelitis with secondary formation of concretions and postoperative infections of the bladder and kidneys occur more frequently than *proteus* cystitis and *proteus* pyelitis

In some cases *proteus* infection is only a harmless postoperative complication, usually, however, it is a severe disease Less often it leads to the loss of a kidney, and it may even result in death of the patient The disease is generally tenacious and resists therapy The best results are obtained by surgical intervention (removal of calculi or nephrectomy) if this is possible The usual urinary disinfectant lavages and chemotherapy rarely affect the infection Vaccine therapy is often efficacious Cicatrization in simple or postoperative infection may be extensive Toxic symptoms are common and may be severe

Strain³⁸ reports that trichomonas infection in males is commoner than is generally realized A freshly voided warm specimen must be examined before the diagnosis can be excluded A specimen of

37 Stul, T Die Harnwegsinfektion mit Bact. *Proteus* Hauser. *Heb. d. Chir. acta* 12 638-657 (Dec) 1945

38 Strain R E Trichomonas in the Male *J. Urol.* 54 433-435 (1945)

has stood for a short time is not satisfactory. In 3 cases in which the patients were boys less than 6 years of age no pus cells were noted in the urine. When treatment with calcium mandelate was given symptoms were relieved and trichomonas disappeared. Treatment in cases in which secondary infection has taken place is less successful, probably because of failure of contact of the medication with the trichomonas. In such cases it should be suspected that trichomonas are being harbored in small abscesses of the prostate, and drainage of these abscesses will be necessary for cure.

TREATMENT

Irmisch,³⁹ in a study of penicillin therapy for sulfonamide-resistant gonorrhea, found that in 200 (41.4 per cent) of 483 cases of gonorrhea smears and cultures were sterile after administration of one of the sulfonamide drugs for five days. In 283 cases (58.6 per cent) the disease was resistant to the sulfonamide treatment received during the prescribed five day course. In 271 cases, or 95.8 per cent, of the 283 cases of sulfonamide-resistant gonorrhea, smears became sterile after 100,000 units of penicillin had been administered as described. In the 12 remaining cases the condition responded to administration of additional penicillin and resulted in an over-all rate of cure of 100 per cent. The lignin test is described, since it is thought to be of value in the detection of concealed sulfonamide therapy.

Allemann and Kriwaczek⁴⁰ report 600 cases of subacute and chronic infections of the urinary tract, treated with silver chloride Metem 4 per cent, a Swiss preparation. Eighty-five per cent of the patients recovered after short periods of treatment. There were no cures obtained when residual urine was present if the infection was tuberculous.

Evley⁴¹ states that penicillin has a definite value in the treatment of pyogenic cocci in the urinary tract. With few exceptions, organisms unable to inactivate penicillin were susceptible to its action, if free urinary drainage was present and anatomic abnormalities were previously eliminated. Ample doses should be given to prevent development of resistant strains by the organism. The successful treatment of staphylococcal infections requires twice the dose necessary for treatment of streptococcal

39 Irmisch, G. W. Penicillin Therapy for Sulfonamide Resistant Gonorrhea. *J. Urol.* **55** 306-308 (March) 1946.

40 Allemann, R. and Kriwaczek, E. Die Behandlung infektiöser Erkrankungen der Harnwege mit Silber Metem extern (Silberchlorid Metem 4%). *Schweiz. med. Wchnschr.* **76** 9-12 (Jan. 5) 1946.

41 Evley, M. Penicillin Treatment of Urinary Infections Caused by Pyogenic Cocci. A Report of One Hundred and One Cases. *J. Urol.* **55** 435-439 (April) 1946.

infections. Ealey's best results were obtained with a daily dose of from 200,000 to 350,000 Oxford units for from three to six days. The local use of penicillin was found to be an excellent adjuvant in postoperative treatment in 3 cases.

REITER'S DISEASE

Sargent ⁴² discusses Reiter's syndrome and presents 3 cases in which the urologic aspect of the typical symptomatic triad of arthritis, conjunctivitis and urethritis was striking and the urethritis had extended until severe cystitis was present. The cause of the disease is unknown, and no treatment which materially affects the course of the disease has been found. Sargent suggests the term "idiopathic blennorrheal arthritis."

42 Sargent, J. C. Reiter's Syndrome, *J. Urol.* 54: 556-564 (Dec.) 1945.

BURNED AND TRAUMATIZED HANDS

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MAJOR surgical conditions of the hands befalling soldiers are common and present a most serious problem. There are two main groups into which these problems may be classified (1) burns and (2) trauma.

Burns and trauma of the hands are particularly important because of the loss of function which frequently follows these conditions. Burns and trauma to other parts of the body may often be considered as problems in healing and cosmetics, but rarely do they present problems in function as complex as the function of the hands. From the time that first aid is administered, function of the hands must be considered. Otherwise disaster is met.

BURNS

First degree burns and second degree burns, unless extremely extensive, are rarely serious problems. Burns involving all the layers of the skin and those involving skin and deeper structures are most serious. The so-called third degree burn will be especially considered.

The Army makes great effort to prevent burns by emphasizing the dangers associated with handling gasoline and other inflammable materials and by instituting suitable safety measures. However, in modern warfare, with flame throwers and high explosives, burns are inevitable.

Burns of the hand most often accompany burns of other parts of the body. In the early management of a burn casualty the primary considerations are (1) prevention and control of shock, (2) prevention of contamination of the surface of the burn during treatment and evacuation and (3) application of a sterile pressure dressing on the burn.

Initial Care—In the initial care of the patient pain is controlled by morphine. In extensive burns a $\frac{1}{2}$ grain (30 mg) dose of morphine may be necessary. In shock, anoxia may be present and large doses of morphine are dangerous. In such circumstances the dose should not exceed $\frac{1}{4}$ grain (15 mg). In shock, absorption of morphine given subcutaneously or intramuscularly may be delayed in which case repeated doses of morphine should be given with caution. Relief of shock and improvement in peripheral circulation may lead to rapid absorption and overdosage if administration of morphine has been

repeated in such cases. Careful intravenous administration of morphine has the advantage that pain is more promptly and certainly controlled and the danger of overdosage from repeated subcutaneous or intramuscular administration is nullified. A dosage of $\frac{1}{6}$ to $\frac{1}{4}$ grain (10 to 15 mg.) given slowly in 10 cc. of sterile water or isotonic solution of sodium chloride and repeated as necessary is perhaps the safest method of intravenous administration of morphine.

Early therapy for replacement of plasma is instituted. If evacuation cannot be carried out quickly to a place for definitive therapy, administration of plasma is started as part of the first aid measures. If 1 or 2 units of plasma are given early, even in the first half-hour, life may be saved. Quantities of plasma up to 12 units may be required in the first twenty-four hours for extensive burns. If a patient is in shock when administration of plasma is started, the first 2 or 3 units should be given rapidly. The best laboratory methods for investigating the severity of shock are determination of the red blood cell count, hematocrit reading, specific gravity of the blood and hemoglobin content of the blood. These determinations govern the quantity of plasma to be given. Determinations of blood chloride, potassium and protein levels and carbon dioxide-combining power are of value.

From the first, efforts should be made to prevent contamination of the surface of the burn by organisms from the nose and throat. Persons handling a patient should always be masked. Aseptic technique with gloves and instruments, if possible, should be used at all times.

No cleansing or debridement is attempted in the field. This procedure is performed in hospitals, where complete facilities for definitive treatment are available. A fresh burn is covered with a sterile prepacked dressing, and the patient is evacuated to a hospital for definitive treatment as quickly as possible. Boric acid ointment or petrolatum is not applied to a grossly contaminated burn, because they complicate the later cleansing of the burned surface. If a local application is considered necessary, 5 per cent sulfadiazine cream is preferred because of its bacteriostatic effect and its relative ease of removal later if cleansing and debridement are considered necessary. Sulfadiazine is not absorbed from a burned site, and care must be exercised to prevent excessive dose.

Severe burns of the hands or of one hand alone have been recognized by the Army as major burns, and the patients are evacuated to a hospital for definitive treatment. Administration of tetanus toxoid is indicated for all patients with second or third degree burns. With gross contamination sulfadiazine therapy may be instituted in the field.

Definitive Care—Phase I. Control of Shock. Morphine is given to relieve the patient's pain. Shock is treated with plasma.

Phase 2 Operation and Control of Infection Cleansing and debridement are performed oftenest with the patient under general anesthesia Pentothal sodium is usually used A brachial block is suitable in some cases Gross dirt is removed by immersion of the patient's hand in a basin of sterile soap and water and swabbing the hand gently with sponges Oil and grease are removed with ether After cleansing, the hand is prepared and blebs are excised Devitalized tissue is removed A culture should always be taken of the bleb fluid or of the burned site

Aldrich and Firor¹ have shown that beta hemolytic streptococci and gamma streptococci usually contaminate a burn, and culture of these organisms may be obtained within twenty-four hours The first culture is tested for sensitivity to penicillin and sulfadiazine, and chemotherapy is begun in extensive burns before the result of the culture is reported Repeated cultures may be taken

Test for sensitivity to penicillin A trench plate technic is used to determine the sensitivity of an organism to penicillin A blood agar plate is used, and a trench 1 cm wide is removed from the middle of the plate The trench is filled with a mixture of agar and penicillin containing 1 unit of penicillin per cubic centimeter of the mixture Care is taken to cool agar below 50 C before the penicillin is added The plate is streaked with the standard strain and with the organism to be tested Inhibition of the standard strain averages about 8 to 10 mm Insensitive strains occasionally grow across the penicillin-filled trench

Freshly prepared plates must be used for each test, otherwise the penicillin diffuses throughout the plate

Test for bacteriostatic power of patient's serum An attempt is made to determine whether or not the patient is receiving enough penicillin by testing the patient's serum for a bacteriostatic level A sample of the patient's blood is obtained and the serum separated, sterile technic being used Four test tubes are set up containing the following contents (1) undiluted serum, (2) serum diluted 1:2 with broth (3) serum diluted 1:4 with broth and (4) broth without serum, for a control If facilities permit, a more accurate estimation of the amount of penicillin in the blood serum can be obtained by making dilutions up to 1:32 or 1:64 Each tube is inoculated with a loopful of a diluted (1:1,000 or 1:10,000) twelve hour broth culture of the patient's organism After twelve hours' incubation, the result may be determined either by inspection or by subculture on agar plate The latter is more desirable If the serum is bacteriostatic, the first tube should show no growth, frequently inhibition is noted in the second and third tubes as well Repeating this procedure on samples drawn at hourly intervals

1 Aldrich, R H New England J Med 208:299 1933

between two successive doses gives an indication, first, as to whether the patient is receiving enough penicillin to produce bacteriostasis and second, as to whether the bacteriostasis persists throughout the interval between doses.

Bacteriologic studies are made for aerobic and anaerobic organisms. A period of inadequate penicillin therapy may render a sensitive organism penicillin resistant. This is important in determination of penicillin dosage. For serious infections an initial intravenous dose of 20,000 units should be given. This should be followed by intramuscular doses of 10,000 to 20,000 units every two hours until the infection is under control or proved to be resistant to penicillin. Sulfadiazine is the sulfonamide drug of choice.

Test for sensitivity to sulfonamide drugs. A broth medium with 20 volumes per cent of a sulfonamide drug may be used, inoculated with the etiologic bacteria. Other broth mediums with 10 volumes per cent, 5 volumes per cent and $2\frac{1}{2}$ volumes per cent of sulfonamide compound may also be inoculated. If growth is inhibited with a broth medium containing 10 volumes per cent of a sulfonamide drug, the organism is sulfonamide sensitive. However, this sensitivity test is inaccurate because peptones in the broth inhibit action of sulfonamide compound. The best indication for sensitivity of an organism to a sulfonamide drug is the clinical reaction of the infection to the drug. An initial dose of 4 Gm. of sulfadiazine is given and then 1 Gm. every four hours until signs of acute infection have subsided for forty-eight hours. The dosage gives adequate concentration in the blood to carry out bacteriostasis. Toxic reactions are minimal.

If a choice were to be made in chemotherapy, penicillin would probably be the drug of choice. The sensitivity of the organism to the drug can be more accurately tested with penicillin, and reactions to penicillin are fewer than those to sulfadiazine. However with infections due to gram-negative bacilli sulfadiazine is indicated.

Phase 3. Specific Functional Therapy. A consideration of the function of the hand should be made with no less diligence than consideration of shock and infection. Grave errors have been made in the past because of the lack of proper attention to the function of the hand early in the treatment. In a third degree burn involving the hand the prognosis as far as function is concerned is good. Prognosis is poorer as the burn penetrates deeper to include fasciae, tendons, nerves or the joints and bones.

In many cases it is not possible to tell how much of the burn is second degree and how much is third degree. Four days after the beginning of the burn is about as soon as one can clearly distinguish the extent of the burn. With severe burns of the hand specific therapy should be begun immediately after the debridement.

Changes in physiology and pathologic states of burns of the hands have been ignored too often in the past and have led to irreparable changes in the tissues. The sight of a burned hand which is edematous and indurated and has limited motion in every joint has been much too familiar in civilian practice. The fascial spaces especially on the palm are numerous and accumulations of exudate and fibrosis in these spaces can lead to nothing but limited function.

The present concept of the change in physiology in a burned hand² is that there are damaged capillaries in the burned area which permit the escape of plasma and some whole blood into the intercellular spaces. If there is a complicating burn over a large extent of the surface of the body there is a decreased volume of blood. The resultant impaired circulation with a decreased volume of blood leads to anoxemia throughout the entire body. This anoxemia damages capillaries everywhere so that a dilatation and increased permeability of capillaries in all tissues exists. Specifically as far as the burned hand is concerned, it means that there is a tremendous accumulation of plasma in the intercellular spaces. Fibrosis occurs as a phase in the response of tissue to injury.

Due consideration must be given to the prevention of the accumulation of exudate in the intercellular tissues to the mobilization of fluid accumulation in these tissues and to the prevention of dangerous fibrosis.

Roulston⁴ applied casts to burns of the extremities after maximum swelling occurred and infection was present. Zeno⁵ used plaster casts in fresh burns and felt that the good results were due to the immobilization. Allen and Koch⁶ advocated pressure dressings for burns. Glenn, Peterson and Drinker⁷ showed that the application of a close-fitting cast immediately after the burn would prevent swelling, and at the same time the circulation in the burned extremity was unimpaired. However, impaired capillary flow occurred in the untreated extremity. These investigators reported that the benefits of the treatment decrease according to the amount of swelling that precedes the application of a cast. Levenson and Lund⁸ have recently reported satisfactory results in 23 cases in which close-fitting plaster or paris casts had been used.

Barron⁹ has suggested another method for the mobilization of the intracellular exudate, based on the theory of ionization. He applies a

2 Flynn J E. *Am J Surg* **55** 457 1942

3 Blalock A. *Principles of Surgical Care*. Shock and Other Problems. St Louis C V Mosby Company 1940

4 Roulston T J. *Brit M J* **2** 611 1941

5 Zeno L. *Arch surg de med cir & specialid* **14** 322 1939

6 Allen H S and Koch S L. *Surg Gynec & Obst* **74** 914 1942

7 Glenn W W L, Peterson D K and Drinker C K. *Surgery* **12** 685 1942

8 Levenson S M and Lund C C. *Treatment of Burns of Extremities with Close Fitting Plaster or Paris Casts*. *J A M A* **123** 272 (Oct 2) 1943

9 Barron J. Personal communication to the author

sterile pressure dressing to the burned hand, the upper layer of which is soaked in isotonic solution of sodium chloride. A small rubber tube inserted into the dressing permits isotonic solution of sodium chloride to be inserted as needs be. The anode of a galvanic current is placed on the gauzes soaked in isotonic solution of sodium chloride. He reported excellent results by this method.

In the Army, a patient who is burned in the Combat Zone passes through many hospitals in the process of evacuation. Many different surgeons may treat a patient with burned hands. In such circumstances it would be impractical to apply a tight-fitting cast to the burned upper extremity. The hand is immobilized in a position of function on a molded anterior splint. A firm elastic bandage is then applied to obtain the desired pressure. In some cases it is undesirable to use a plaster splint. A firm elastic bandage applied over the dressing may be suitable.

Method. Most war burns must be debrided and cleansed because of contaminants. The serum from blebs is cultured. A layer of sterile petrolatum gauze is applied over the whole burned site. The petrolatum gauze is also placed between the fingers. Eight layers of mesh gauze are then fitted over the petrolatum gauze to permit absorption of surface fluid. The hand is then supported on a molded anterior splint extending from a point 2 inches (5 cm) above the burn to the tip of the fingers. The desired pressure is then obtained with an elastic bandage. The anterior splint is molded with the hand in a position of function, i. e., the wrist is dorsiflexed to about 35 degrees, the fingers are flexed approximately 40 degrees at all joints and the thumb is flexed about 15 degrees and rotated so that its volar aspect faces the volar aspect of the index finger.

All extensive burns are given chemotherapy. Static motion of flexor, extensor, adductor, abductor, lumbrical and interossei muscle is performed while the hand is in the pressure dressing, fifteen times three times a day.

With hands which are grossly contaminated at the time of the burn dressings must be changed daily. With hands which are relatively clean at the time of the burn, the pressure dressings are not changed for four days. The use of faradic current will give an idea of how much disability will eventually exist. If infection exists local treatment will preserve some of the epithelial islands which may otherwise be destroyed. Over 50 per cent of burns are not in need of more pressure dressing or cast. A small per cent need more pressure therapy. A smaller per cent are found eventually to cause partial or complete ankylosis of some joints. In the last group the patient may be given faradism or exercises to maintain latitude of motion besides immobilization in a position of function.

The largest per cent of patients, who need no more pressure after four days, are now ready for a most important specific functional therapy, which consists in immersion of the burned hand in a sterile solution of warm isotonic solution of sodium chloride. Sterile water should not be used because, with much soaking, some of the cells in the epithelial islands undergo crenation. The hand is immersed in the fluid daily for one hour. Exercises for every joint in the hand and for all tendons and muscles beneath the burn are actively carried out in the bath, at five minute intervals, with the hand continuously in the bath. The exercises follow a definite pattern, with supervision by one who understands the complex mechanism of the hand. Flexion and extension of each phalanx are performed. Abduction and adduction of each finger are next performed. Opponens action of the thumb and little fingers follows. The most important exercise of all is flexion of all fingers at the metacarpophalangeal joints with extension of the fingers. *i. e.*, exercises of the lumbrical and interossei muscles. A hand in which the function of the lumbrical and interossei muscles is maintained is a useful hand. After the bath the hand is dressed with sterile technic. The entire burned site is covered with sterile petrolatum gauze. Sterile gauze is applied over the petrolatum gauze, and the hand is again supported on the molded anterior splint. In two to three weeks, immobilization is no longer necessary.

Many errors have been made in the past in civilian practice. The outstanding errors have been a failure to apply the proper pressure in the early stages of the burned hand and immobilization of the hand in an improper position. The deformity after the hand has been immobilized in a position of extension has been too familiar in the past, with hyperextension of the metacarpophalangeal joint and some flexion of the proximal and distal interphalangeal joints. Flexion of the metacarpophalangeal joint can never be accomplished to a point of any functional value. The hand is not even a useful hook.

In some cases only one or two fingers may ultimately be ankylosed. It is important in such cases to place these fingers in a position of function, otherwise the other fingers, particularly the adjoining ones will not completely flex. The reason is that the flexor profundus of a finger which is ankylosed in a position of extension cannot be drawn proximally through its full excursion by the common flexor profundus muscle. The common flexor profundus is held and cannot fully flex the adjoining fingers.

In the presence of a severe burn in the palm, there is usually a temporary loss of function of the lumbrical and interossei muscles. Prolonged immobilization of metacarpophalangeal joints in a position of extension in the presence of severe burns will lead to contracture of the collateral ligaments and cause limited flexion of the metacarpophalangeal joints.

Phase 4 Skin Grafting Grafting of skin over the burned area must be performed as soon as the recipient site is suitable to receive the graft, to keep contractures at a minimum. Attempts at immediate grafting for the greatest part have been failures. About the earliest that an extensive third degree burn of the hand can be made suitable for grafting is after three weeks. Thiersch or split thickness grafts may be used.

A modification of the Sano coagulum-contact method¹⁰ is of value when the area requiring grafting is irregular and promontories must be covered. Continuous pressure over such a site has always been a problem. Leukocytic suspensions with and without heparin have been used. The recipient area has been painted with the prepared plasma and the graft painted with leukocytic cream. In five minutes the graft is firmly adherent, and the danger of the graft's floating off has been removed.

It has been found that plasma twice as concentrated as that used to combat shock provides a suitable coagulum for the graft. A pressure dressing is applied with the hand in position of function for immobilization. The pressure dressing is removed in one week. Active motion is usually begun one week to ten days after grafting.

If the patient has had an extensive body burn besides that on the hand, it is well to investigate his blood chemistry before grafting. Some failures in grafting have been reported when the serum protein level are low. Especial consideration should be given to the blood protein and vitamin C contents before grafting. Deficiencies in serum protein and vitamin C are easily combated. Proper metabolism is a factor in resisting infection and is also needed for grafting to be successful.

TRAUMA

Trauma of the hands is considered especially from the viewpoint of wounds. The proper treatment of wounds is of paramount importance to the function of the hands. Early but not primary closure is the key to the problem. Wounds of the hands incurred in war present a different problem from wounds in civilian practice. The wounds are usually more mutilating, may be accompanied with other severe wounds, shock and are more frequently contaminated by tetanus bacilli (*Clostridium welchii*) and other pyogens than wounds in civilian practice.

Initial Treatment—General Consideration. Primary care of the hand is not concerned with debridement of wounds but is directed to: (a) prevention of infection (b) control of hemorrhage (c) relief of pain (d) adequate immobilization and (e) prevention of traumatic shock.

(a) **Prevention of Infection.** An increase in contamination is prevented by masking the nose and mouth and by disinfecting the hands.

probing or manipulation of the wound. Only superficial foreign bodies are removed. Antiseptics such as ether, alcohol or iodine are never introduced into the wound. A large sterile dressing, fixed securely, is applied to prevent further contamination during evacuation. Tetanus toxoid is given. The prophylactic treatment of tetanus has been one of the outstanding contributions of surgery in this war. Twenty thousand units of penicillin are usually given at a forward echelon and administration of the drug is repeated along the line as needs be. Four grams of sulfadiazine, orally, is given early. One gram is then given every four hours. Chemotherapy is continued at all points in evacuation, even on hospital trains.

(b) Control of Hemorrhage. The hand is elevated, and an accurate and firmly applied pressure dressing controls most bleeding. Active arterial hemorrhage from a vessel which is visible in the wound may be checked by clamp and ligation. A patient is not evacuated until bleeding is controlled.

(c) Relief of Pain. In all cases adequate sedation is provided during examination, treatment and evacuation.

(d) Immobilization. All large wounds, even those without associated fractures are immobilized during evacuation. The hand is supported on a molded anterior plaster splint with the hand and fingers in a position of function. The hand is kept elevated to prevent edema.

(e) Prevention or Treatment of Shock. Shock is combated by (1) control of pain (2) immobilization of the injured part and (3) administration of plasma (in general 1 or 2 units of plasma may be given to all patients with extensive wounds regardless of the circulatory state). If there is a circulatory collapse plasma and blood in amounts of 1,000 cc or more are given. Patients in shock are not evacuated.

In a wound of the extremity a note describing the presence or absence of paralysis or evidence of interference with the vascular supply of the extremity is made.

Definitive Treatment—General Considerations. The extent of the injury is determined at once by an examination of motor functions and sensation of the hand. An estimate of the injury to tendons, muscles and nerves is made before the wound is inspected. An inspection of the wound is made. A culture of the wound is taken. Great care is taken to avoid further contamination by careless dressings or talking into the wound. Roentgenographic examination is done to localize foreign bodies preceding operation. Debridement of large wounds is delayed until shock has been adequately treated by plasma or whole blood. Unnecessary manipulation of the wound is avoided until operation is completed. Before the dressing is removed preliminary to debridement, the soiled skin is cleaned with soap and water.

The wound is protected from the cleansing agents with sterile gauze. All hair is removed from the margins of the wound by shaving. Nails are clipped and trimmed. Preoperative preparations of the skin are simple soap and water scrub, followed by the application of ether, iodine and alcohol. Antiseptics are not introduced into the wound.

Debridement is always done under strict aseptic precautions, even when the wound is small. Multiple wounds due to small metallic foreign bodies do not require debridement. Simple cleansing with soap and water, frosting with sulfanilamide and application of a sterile dressing are adequate. Multiple small, superficially embedded foreign bodies are often best removed by scrubbing with a brush.

The wound is gently irrigated, sterile isotonic solution of sodium chloride being used. Irrigation is best accomplished by a gravity apparatus. The nozzle of the tube is placed into the deepest part of the wound, irrigation being done from within outward.

The extent of the underlying damage cannot be predicted from the appearance of the external wound. A small superficial wound may often lead into a larger wound of the deeper structures. In such cases incisions extending into the wound may be necessary to obtain adequate exposure. Such incisions are made in the long axis of the extremity. In the region of the joints the resultant scarring and possible contracture are decreased if the incision in the skin is made in the direction of the lines of cleavage of the skin transversely.

A small margin of skin is excised. It is rarely necessary to excise more than $\frac{1}{8}$ inch (0.32 cm.) margin. All hemorrhagic and coiled subcutaneous tissue is excised. All readily accessible foreign bodies are removed, especially important are pieces of clothing and other non-metallic materials. A prolonged search involving extensive exploration for relatively small foreign bodies is not indicated. Conservation is emphasized in removing fragments of bone. Only bone which is detached from the muscle, periosteum or a larger piece of visible bone is removed.

Repair of the tendons is not attempted except in the most ideal circumstances and these circumstances are most rare. After debridement, hemostasis and irrigation are complete, the wound is frosted lightly with sulfanilamide powder. No wound of the hand, regardless of the size, is closed primarily. However, an effort is made to cover delicate structures such as nerves, tendons and blood vessels with soft tissue. The wound is packed loosely. Tight packing is avoided. Drainage is afforded by gentle insertion of petrolatum gauze with ends protruding beyond the margins of the wound. The wound is covered with a large, sterile absorbent dressing held in place by means of a firm but not tight, applied bandage. In the postoperative management

the wound, every effort is made to prevent secondary contamination by use of sterile technic and masking of the physician's nose and mouth while he is dressing the wound

Treatment of Gas Gangrene The most important factors in the prevention of gas gangrene are the thorough and complete debridement of devitalized muscle and the early replacement of blood. The most important factor in the treatment of established gas gangrene is early removal of all involved tissue. This frequently necessitates excision of entire muscle bellies or guillotine amputation. Chemotherapy is maintained. Administration of polyvalent gas gangrene antitoxin is of questionable value but may be used. Polyvalent gas gangrene antitoxin is administered, preferably intravenously after suitable precautions against anaphylactic shock have been taken. An initial dose of 4 vials (26 000 units in each vial) is given intravenously. Additional injections of 3 or 4 vials every four to six hours for two to three days should be administered. Because of the fact that in gas bacillus infection there is rapid destruction of erythrocytes transfusions of whole blood are used.

Specific Considerations In the management of war wounds of the hand the importance of early secondary closure or early skin grafting cannot be overemphasized. An early covering of a wound of the hand means less edema, less induration, less infection and less scar tissue with its accompanying contractures. Consideration for specific functional treatment of the hand is never more striking than in the early closure of war wounds. Closure of wounds of the hand takes precedence over therapy of lacerated tendons, injuries to the nerves and fractures.

The ideal time for closure of a wound by secondary suture or grafting has been a problem which experience has answered. The fourth or fifth day after debridement seems to be the earliest that such wounds should be closed. After debridement and cleansing, the wound is not dressed for four days unless a rise in temperature, a rapid pulse, pain and increased local heat are encountered, suggesting infection.

Technic of secondary closure may vary If at the time of debridement and cleansing the wound appears clean, silk sutures may be placed in the wound and left untied. On the fourth day, with the patient under pentothal sodium anesthesia, the skin about the wound may be prepared with ether and alcohol and the sutures tied in place. This procedure provides a minimum of operative trauma and a minimum of anesthesia in a patient who may have previously been in shock and who may previously have had an extensive debridement and cleansing.

If the wound is grossly contaminated and dirty at the time of debridement and cleansing no sutures are placed in the margins of

the skin. If there are no symptoms or signs of infection for four days, the dressing is removed on the operating floor and a culture is taken, if there is no gross evidence of sepsis, the edges of the skin are approximated without undercutting. If there is gross evidence of infection when the dressing is removed, a culture is taken, no closure is performed and the infection is treated by chemotherapy and local measures. The wound is inspected daily until all clinical evidence of infection has been quiescent for forty-eight hours. Despite lack of clinical

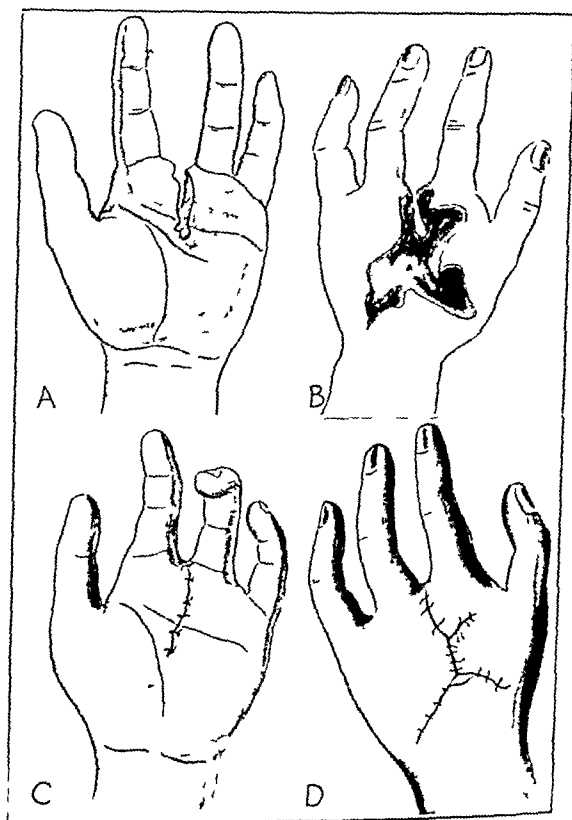


Fig 1 (case 1)—A anterior view preoperatively B posterior view preoperatively C anterior view postoperatively D, posterior view postoperatively

evidence of infection, a culture may show contaminating organism in the wound. Despite the presence of these contaminating organisms the wounds are secondarily sutured loosely. About 90 per cent of wounds can be closed on the fourth day.

CASE 1—Case 1 is an example of a case in which a patient received a wound of the hand which became septic. Sepsis was controlled and a suture performed (fig 1).

A rifleman was shot by a rifle bullet (30 mm) in his left hand while in action with the enemy at about 1:45 p.m. on July 26, 1944 in Normandy, France. The wound of entry was on the palm and the wound of exit on the dorsum. The same day the patient was given first aid treatment at a battalion aid station. Sulfanilamide powder was dusted on the wound and a sterile dressing applied. Tetanus toxoid was given. The patient was then passed through a clearing station to an evacuation hospital. At about 7 p.m. on July 26 operation was performed at the evacuation hospital. A debridement of an extensive through and through wound of the hand was performed. The middle finger and the distal half of a shattered third metacarpal bone were removed. The wound was dusted with sulfanilamide powder, and petrolatum gauze was placed loosely in the wound. A plaster cast was applied with the hand in a position of function. The patient received a transfusion of 500 cc of whole blood. Penicillin therapy, 20,000 units every three hours, and sulfadiazine 1 Gm every four hours, were given.

On July 29 the patient was evacuated by air to a holding general hospital in England. Administration of penicillin and sulfadiazine therapy were continued. On July 31 the patient was transferred by hospital train, in which penicillin and sulfadiazine were given to a general hospital.

At a general hospital on July 31 a roentgenogram revealed an absence of the middle finger and the distal half of the third metacarpal on the left hand. The cast was removed. Examination of the left hand revealed that the third finger was absent. A wound which actually split the center of the hand was found. The wound over the distal half of the palm measured $2\frac{1}{2}$ by 1 inches (6 by 2.5 cm). The wound over the dorsum of the third metacarpal measured 3 by 2 inches (7.6 by 5 cm). The wounds contained much slough and pus.

A culture taken from the wound on July 31 showed nonhemolytic *Staphylococcus aureus*, nonhemolytic streptococci and gram-positive anaerobic spore-forming rods (*Clostridium welchii*). The organisms were sensitive to penicillin.

The patient was treated with penicillin until August 10. Hot chlorinated soaks were used four times a day, locally through August 11. The hand was immobilized with a cast in a position of function. On August 10 there was no frank pus in the wound, and all slough had been excised.

A culture of material from the wound on August 10 revealed nonhemolytic *Staph. aureus* and gram-negative rods. Despite the culture a secondary closure of the wound was performed on August 12 with the patient under pentothal sodium anesthesia. Edges of the skin were approximated without undercutting. Five sutures were taken in the palm, two sutures in the web between the index and ring fingers and sixteen sutures in the dorsum of the hand. Postoperatively the hand was immobilized in a position of function. On August 19 seven days postoperatively the cast was removed, all sutures were holding. Less edema and induration were found than preoperatively. One half of the sutures were removed on the seventh day postoperatively. The remaining one half of the sutures were removed on the ninth day postoperatively and active motion of all fingers was begun. Two weeks postoperatively all motions were within normal range.

All wounds of the hands cannot be closed by secondary sutures. Grafting may be necessary. Early grafting cannot be performed with burns of the hands but early grafting must be performed on traumatic wounds of the hands. The same general principles hold for grafting in a hand that have been stated for secondary suture of the wounds. The earliest feasible time is four to five days following debridement. If the

wound is clinically clean four days after debridement, a split thickness graft may be applied. If tendons, nerves, blood vessels and bones are exposed, split thickness grafts will not take in those regions. A full thickness pedicle graft is then indicated. Full thickness grafts are preferable for defects of the palm.

If the wound is found septic, four days after debridement chemotherapy and local treatment in the form of hot soaks are given. When sepsis is controlled and the wound is grossly clean for forty-eight hours, grafting may be done. However, the results of the culture are a factor in determining the treatment. If there is no growth, a split thickness graft in the form of the defect may be applied.

If the culture reveals the presence of pathogens, "postage stamp" grafts may be applied. A "postage stamp" graft is a split thickness graft. This graft may be removed from the donor site by a Paget dermatome or by a free hand cutting. The split thickness graft is then placed with its external surface on a strip of petrolatum gauze. Grafts about $1\frac{1}{2}$ inches (3.5 cm) square are cut. Concentrated plasma as an adhesive coagulum, is placed on the under surface of the graft. The square of graft and petrolatum gauze are then placed on the recipient site. A space of about 1 inch may be left between the grafts. It is wise to use some form of pressure over these grafts. The coagulum helps to retain the graft on the recipient site. However, serum is found in the spaces between the grafts, and this could be a factor in loosening the graft. Sterile petrolatum strips are placed over the entire wound after grafting, sterile gauze is then applied and sterile cotton waste is applied over the gauze. Pressure is obtained by four sutures which are placed in the edges of the skin and tied firmly over the cotton waste in crucial fashion.

CASE 2—Case 2 is an example of a case in which a patient received an extensive wound of the hand which became septic. After sepsis was controlled and appeared grossly clean, a culture showed contaminating organisms. "Postage stamp" grafts were applied (fig. 2).

The patient received injuries to his left hand, right thumb, both eyes and face as a result of fragments from an enemy 88 mm shell which exploded in combat at about 9 p. m. on July 27, 1944, near St. Lo, France. Present consideration will be mainly of the wound to his left hand. Shortly after the injury the patient received first aid treatment at a battalion aid station. Sulfanilamide powder was dusted on the wound of his left hand and a sterile dressing applied. Tetanus toxoid was given.

The patient was transferred to a field hospital, where operation was performed at about 12 p. m. on July 27. At this hospital a roentgenogram revealed an absence of the index finger and middle finger, which had been blown off, a dislocation of the thumb at the metacarpophalangeal joint with a severely comminuted fracture of both phalanges of the thumb, comminuted fractures of the greater and lesser multangular bones, complete absence of the second and third metacarpal bones, which had been blown off, comminuted fractures of the fourth

and fifth metacarpal bones, and a severely comminuted fracture of the proximal phalanx of the ring finger.

The wound on examination, was dirty and ragged. The thumb was attached by a small tab of skin. The index and middle fingers were absent. The second and third metacarpal bones were absent. There was some function by the flexor and extensor muscles to the ring and little fingers.

At the field hospital a debridement and irrigation of the wound were performed. The left thumb, which was avascular, was amputated. Sulfanilamide

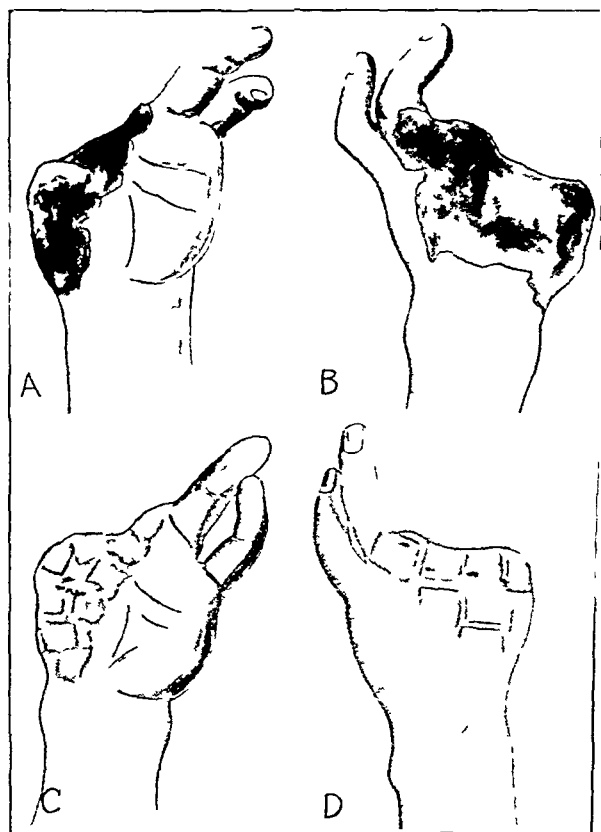


Fig 2 (case 2)—Anterior (A) and posterior (B) views preoperatively. Anterior (C) and posterior (D) views postoperatively.

was dusted on the wound and a cast applied. Therapy with intramuscular administration of penicillin and oral use of sulfadiazine was given. Transfusions of whole blood were given.

Two days after injury, July 29, the patient was evacuated by air to a holding general hospital in England, where sulfadiazine and penicillin therapy was continued.

On July 31, the patient was transferred to a general hospital. A roentgenogram was taken. The cast was removed, and the wound was inspected. Examination revealed an extensive avulsed wound. The thumb and index and middle

fingers on the left hand were absent. The wound measured 4 by 3 inches (10 by 7.6 cm) over the palm and 5 by 3 inches (12.7 by 7.6 cm) over the dorsum. The wound was grossly septic and contained slough. No attempt was made at early closure. Material for culture was taken. Culture revealed anaerobic gram negative rods (*C. welchii*), nonhemolytic streptococci, hemolytic *Staph aureus* and aerobic gram-negative rods.

Penicillin and sulfadiazine therapy and hot soaks were continued until August 8. On this date the wound appeared grossly clean. The head of the first metacarpal bone and the devitalized ends of a few tendons were exposed in the wound. A culture of material from the wound made on August 8 revealed anaerobic gram negative rods (*C. welchii*), nonhemolytic streptococci and hemolytic and non hemolytic *Staph aureus*. Despite this culture, "postage stamp," split thickness grafts were applied on August 10 and a cast applied. Seven days postoperatively, Aug 17, 1944, the grafts were inspected and complete takes were found. Ten days postoperatively the cast was discarded and active motion begun. Two weeks postoperatively there was normal motion of the little finger and flexion was three-fourths normal in the ring finger.

This patient had an enucleation of his left eye on August 21 for an eye with lacerations of the cornea, in which the pupil was not visible, and with hemorrhage in the anterior chamber.

Many wounds of the hand are suitable for a combination of secondary suture and skin grafting. As much of the hand as possible should be closed by secondary suture provided that the resultant scar will not lead to a contracting deformity. Early closure of the wound is again stressed when this combination is used.

CASE 3—Case 3 is an example of a case in which a combination of secondary closure and skin grafting were used (fig. 3).

An infantryman was shot in the base of his right thumb by a fragment from an 88 mm shell at about 1:30 a.m. on July 28, 1944, near Pierre in Normandy, France. First aid consisting in dusting the wound with sulfanilamide powder and application of a sterile dressing, and injection of tetanus toxoid was administered at a battalion aid station. Almost five hours after injury, the patient was operated on at an evacuation hospital. A roentgenogram revealed a fracture of the first metacarpal bone with a wide dispersion of fragments. The proximal one fourth of the first metacarpal bone was all that was intact. The distal three fourths of the bone was blown away. Three small fragments of bone remained where the distal three fourths of this bone should have been found. At the evacuation hospital a debridement and cleansing of the wound were performed. Penicillin and sulfadiazine therapy was instituted. A cast was applied with the thumb in a position of function. On July 29, 1944, the patient was evacuated by air to a holding general hospital in England. On July 31 the patient was admitted to a general hospital.

On August 1 a roentgenogram was taken, the cast removed and the wound inspected. There was no motor function of the thumb. There was some sensation over the dorsal aspect of the thumb. An extensive wound was found at the base of the thumb. The wound extended from the dorsal aspect of the thumb over the lateral and volar aspects to the dorsomedial aspect. The wound measured 4½ inches (11 cm) in length. The muscles and tendons which were cut included both flexors, both abductors, both extensors, the opponens and the adductor pollicis. The thumb dangled by skin and fascia over the dorsum. However, the circulation appeared adequate.

The wound contained slough and pus. No closure was attempted. A culture revealed nonhemolytic *Staph aureus*, nonhemolytic streptococci, *Cl welchii* in small numbers and aerobic gram-positive rods. Administration of penicillin and sulradiazine and hot chlorinated soaks were continued through August 20, when the wound appeared clean.

A culture made August 20 revealed hemolytic and nonhemolytic *Staph aureus*, gram-negative rods of the coliform groups and *Cl welchii* in small numbers. Despite this culture a secondary closure was performed on August 22. Five silk sutures were placed over the dorsal and lateral aspects of the thumb. A split thickness graft was placed in the wide defect over the volar aspect. A

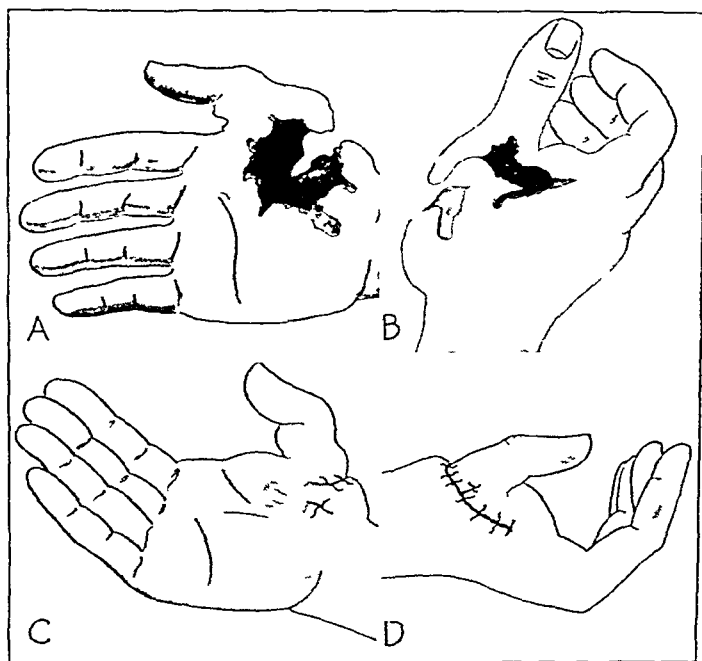


Fig 3 (case 3)—A anterior view preoperatively. The thumb is adducted to accentuate the defect. B posterior view preoperatively. C anterior view postoperatively. D posterior view postoperatively.

plaster cast was applied. On August 29, one week after the operation the cast was removed. The graft had completely taken and the sutured area was healing. A plaster cast for the thumb only, immobilized in a position of function, was used for many weeks.

This case represented one in which amputation of the thumb may have been justified. However, if it had been performed the patient would have only a hook for a hand, and 50 per cent function of his right hand would be lost. Enough callus may form about the fragments of the first metacarpal, so that stable ankylosis with the thumb in a position of function may be obtained. With ankylosis of the thumb

in a position of function a useful physiologic forceps will be had as far as his right hand is concerned

Pedicle grafts may be used for extensive wounds of the hand which are clean four days after debridement, especially in cases in which bones and tendons are exposed or in patients who have had a minimal infection which is quickly controlled. A full thickness graft is especially indicated for the part of the hand which will be exposed to work and trauma, i. e., the palm

CASE 4—Case 4 is an example of a case in which a patient had a minimum of infection and slough in which case a pedicle graft was used (fig 4)

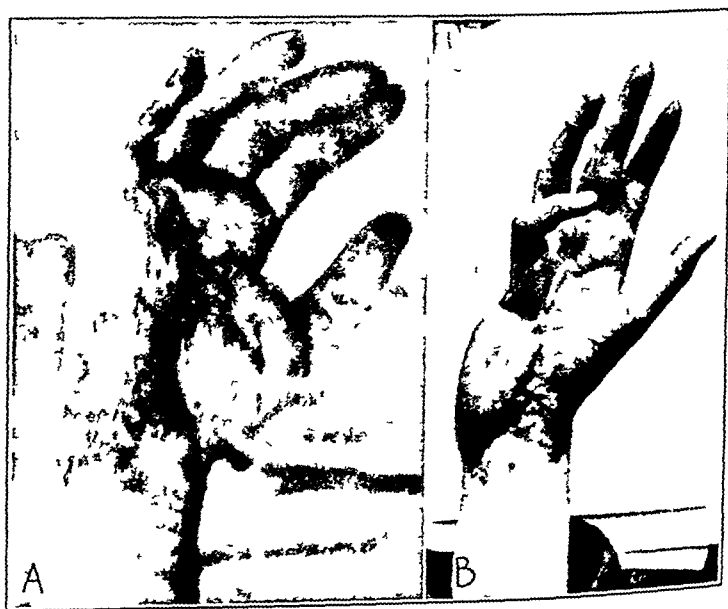


Fig 4 (case 4)—Preoperative (A) and postoperative (B) views

The patient, 22 years of age, received wounds of his right wrist right hand left hand and right thigh from flak of an exploded shell while serving as a bombardier in a B-17 on an operational mission over enemy territory at about 10 30 a m on January 5, 1944. About three hours after being wounded debridement, cleansing and sulfadiazine therapy were given at a station hospital. The right hand received the severest injury, and this will be the only injury considered. He was treated for sixteen days at the station hospital and transferred to a general hospital on Jan 21, 1944.

A roentgenogram of the right hand and wrist showed fractures of the capitate and hamate bones and the proximal end of the fourth metacarpal. There were a fracture and partial absence of the triquetrum and the proximal half of the fifth metacarpal bone. Soft tissues showed multiple opaque foreign bodies.

The wound was inspected, and a slight amount of slough and pus was found. A granulating mass was found to involve the medial one half of the palm and

wrist and extended around to the dorsal region of the fifth metacarpal bone. The granulating area measured 5 by 4 inches (12.7 by 10 cm). The ulnar nerve was apparently destroyed at the time of the injury, because the patient had no sensation over the distribution of the ulnar nerve. He was also unable to abduct and adduct the index, middle, ring and little fingers. There was no function of the flexor digitorum sublimis or profundus tendons or of the lumbrical muscle of the little finger.

A culture of material from the wound revealed hemolytic and nonhemolytic *Staph aureus*, nonhemolytic streptococci and aerobic gram-negative rods. Sulfadiazine therapy was continued. The patient also received hot soaks. Active motion of the fingers was begun. On February 12 the wound was free of slough and pus. A culture on February 12 revealed hemolytic and nonhemolytic *Staph aureus* and nonhemolytic streptococci. Despite the culture, on February 14 a full thickness pedicle graft was freed from the abdomen and sutured to the granulating surface of the hand. On February 24 the graft was found to have completely taken and was cut free from the abdomen. The defect on the abdomen was closed by suturing and split thickness graft. On February 26 physical therapy and active motion were begun.

The little finger was later amputated because of lack of sensation and loss of all motion due to injury of the tendons. By June 1, 1944, flexion and extension of the wrist were one-half normal. Adduction of the wrist was one-fourth normal. Motions of thumb and index finger were normal. Flexion of the middle and ring fingers was three-fourths normal.

This paper will not consider the problem of nerve suture, secondary sutures of the tendons, tendon transplant and the treatment of fracture, because these follow the course which has been well devised in civilian practice.

SUMMARY

One of the most important surgical advances in this war is the fact that war wounds have been early and safely healed after secondary closure or skin grafting. It is basically sound to leave war wounds open after the initial debridement, and this principle has saved many hands, limbs and lives by preventing sepsis. It is not basically sound to leave wounds open indefinitely after the danger from sepsis has passed. Early closure of wounds caused by burns or trauma eliminates pathologic processes that result in dense scar formation, ischemia, sloughed tendons and bones and loss of function.

Success of early closure of burns and traumatic wounds is due to the good condition of the patient and the good condition of wounds at the time the patient reaches the general hospital. Penicillin and sulfonamide drugs are important factors in controlling infections. However, other factors of equal importance to chemotherapy in obtaining good functioning results in wounds of the hand are early and adequate debridement and cleansing, control of shock and hypoproteinemia, the maintenance of a good nutritional state, judgment in closing wounds and the institution of early motion in the involved hand. About 90 per cent of traumatic wounds may be closed four days after debride-

ment With traumatic wounds, moderate pressure with cotton waste and immobilization in a plaster cast help hemostasis, control edema and permit active motion in seven to ten days after closure

The application of a pressure dressing to the burned hand as early as possible helps to prevent the accumulation of exudate in tissue spaces. In four days, the dressing is removed and most of the patients may be started on active motion of the hand in a bath of isotonic solution of sodium chloride. Three weeks is about the shortest period after which grafts can be applied to severe thermal burns of the hands.

If ankylosis is inevitable with deep burns or severe wounds of the hand, immobilization of the involved part in a position of function is maintained.

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MANAGEMENT OF COLOSTOMIES IN THE FIFTEENTH HOSPITAL CENTER (ENGLAND)

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DURING World War II any general hospital in the Communications Zone received in the course of time a fairly large number of patients with colostomies, performed one to three weeks earlier in the forward area hospitals, in association with wounds of the large bowel. It was therefore important to understand the problems involved, since these patients in most instances, had to have their colostomies closed before return either to duty or to the Zone of the Interior, depending on a number of factors.

It was especially and understandably true during the earlier days of the invasion of the continent that the records returning with patients were at times either inadequate or nonexistent, so that occasionally there was no description of the procedure carried out or of the lesion for which it was performed. Thus the planning of the closure was made considerably more difficult.

One should remember that the picture was further complicated in possibly 50 per cent of the cases by associated injuries, especially to the thorax, small intestine, urinary bladder, urethra, ureter, presacral and sciatic nerves and by compound fractures of the pelvic bones.

The object of colostomy for a wound is (1) to divert the fecal stream from an extraperitoneal rectal wound, (2) to permit the exteriorization of mobilizable injured intraperitoneal colon or (3) to act as a proximal colostomy for protection of a suture line in a segment of nonexteriorizable intraperitoneal colon.

The types of colostomies commonly encountered are two, the first being the double-barreled Mikulicz variety, for extraperitoneal rectal wounds and for injuries in which there is a considerable amount of damage to the bowel, requiring exteriorization and sacrifice of a segment. Associated with the former injury one should institute adequate posterior drainage preferably by excision of the cecum and split of the

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association
Memphis, Tenn. Dec. 5, 1946.

Dr. Bartlett held the rank of lieutenant colonel, Medical Corps, Army of the United States, acting as consultant in general surgery for the Fifteenth Hospital Center.

fascia propria. The second is the loop type of colostomy, for exteriorization of a simple perforation or to act as a proximal colostomy for a non-mobilizable injured segment.

The foregoing procedures are essentially as directed by the office of the chief surgeon. In private practice one would be apt to modify some of these methods, which, however, have been shown to pay big dividends in cases in which many factors are concerned, such as occasional uncertainty as to the exact duration of the injury, the varying severity of the wounds of the bowel and, finally, the difference in individual judgment and experiences of a large number of surgeons working on war casualties.

The largest group of colostomies seen were located in the sigmoid probably because of the high incidence of wounds of the buttocks with rectal perforation. It is my opinion that such a colostomy brought out through a McBurney type of incision on the left side is more satisfactory than that brought out through the left rectus or midline exploratory incision, principally because in the former instance the main incision is more apt to heal without infection and consequently the incidence of postoperative hernia is less common. It must be borne in mind, however, that the muscle-splitting and stab wound type of incision must not be too snug about the colostomy, for in such a case much edema of the bowel ensues and, in addition, obstructive symptoms may result. When a double-barreled colostomy is employed, the limbs should be approximated for a distance of about 4 inches (10 cm) and care taken that the blood supply lies medial to the spur.

When the crushing of the spur preliminary to the closure of a Mikulicz colostomy is contemplated, a moderate amount of edema is no longer regarded as a contraindication to the procedure. It can usually be started about two weeks after the original colostomy by the application of two Ochsner clamps side by side. In between forty-eight and seventy-two hours a cut may be made between the clamps up to their tips rather than waiting for them to slough through, thus saving time. A second and occasionally a third application of clamps is invariably necessary a few days later in order to complete the obliteration of the septum. My colleagues and I have employed routinely a small amount of pentothal sodium intravenously when placing the clamps in order to avoid undue pain to the patient, for this is a different procedure from the application of the regular spur clamp for slow steady crushing as in civilian practice. The latter instrument was not available in the European Theater of Operations.

In general, one must wait about ten days following the final obliteration of the spur in order to permit the resultant edema to disappear and to assure firm adherence of the limbs of bowel adjacent to the site of crushing.

The possible complications of spur crushing are injury to the blood supply of the limbs of bowel if not properly approximated at the original operation so as to assure the blood vessels lying medial to the septum, hemorrhage from the spur, injury to a loop of adherent small bowel and, finally, perforation of the peritoneal cavity by application of clamps past the lowest point of adherence of the limbs

During the preoperative period of colostomy closure roentgenograms of the chest and abdomen were made with particular reference to

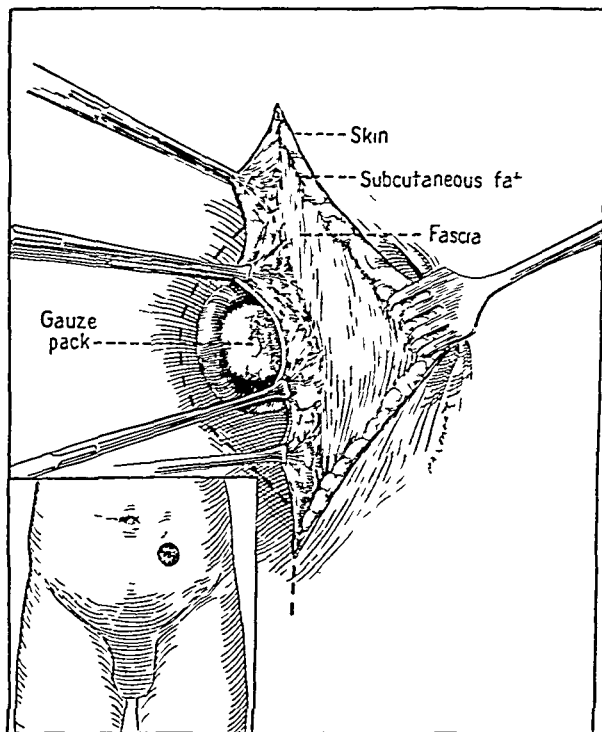


Fig 1—Circumcision of the colostomy opening

foreign bodies and fractures, since, as stated earlier, so many of these conditions were complicated by multiple lesions. Compound fractures of pelvic bones with osteomyelitis and purulent drainage in the neighborhood of a colostomy are an absolute contraindication to repair, as failure will result due to infection in the wound. Then, too, in cases in which a suprapubic cystostomy and colostomy exist in close proximity to one another the wound in the bladder should be permitted to heal before closure of the colostomy is carried out, in order to avoid continual soaking of the wound with urine.

Also during this period of evaluation and preparation these patients were maintained on high protein, high caloric diets with multivitamins added and full correction of any existing anemia or hypoproteinemia made. In addition, barium enemas and proctoscopic examinations were performed, especially in cases in which there had been a rectal wound. Thus it was possible to be certain that a perforation no longer existed at the time of repair. Finally, when the edema was out of the colostomy and the wound was free of active infection, the last steps were taken in the preparation for closure.

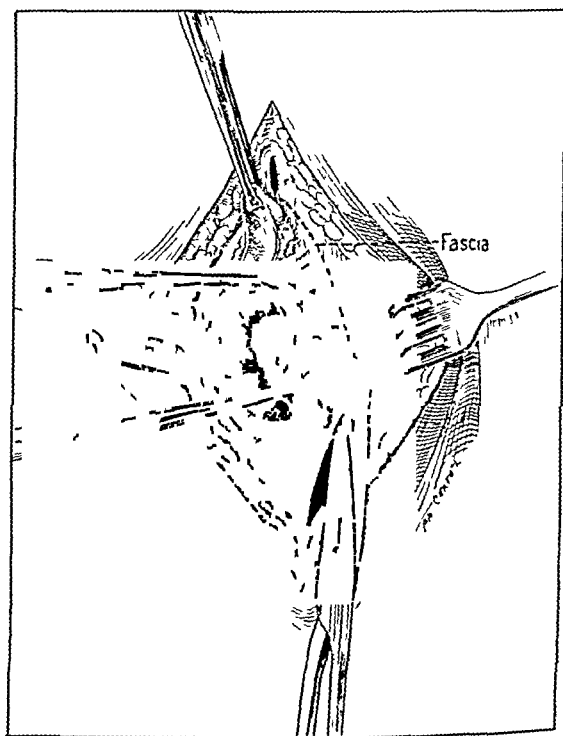


Fig 2—Incision and separation of the fascia and bowel

As part of the immediate preoperative preparation the patient was placed on a nonresidue diet for three to four days and mild catharsis instituted, also, frequent irrigations of both colostomy loops were carried out. Chemotherapy was not employed routinely, however, in the light of present knowledge succinylsulfathiazole should be administered for practically all surgical treatment of the colon because of its probability to lower decidedly the bacterial count. Frequent doses of morphine or opium were given during the final twenty-four

hours and a digital rectal examination made for a possible fecal impaction which might act as an obstructive factor postoperatively.

In the case of sigmoid colostomies we found it useful to permit a button with a string attached to pass down the distal loop a day or two before operation following which the string was fished out through the anus for subsequent use.

TECHNIC OF CLOSURE

Spinal anesthesia with a combination of procaine hydrochloride and tetracaine hydrochloride was employed routinely, and after its administra-

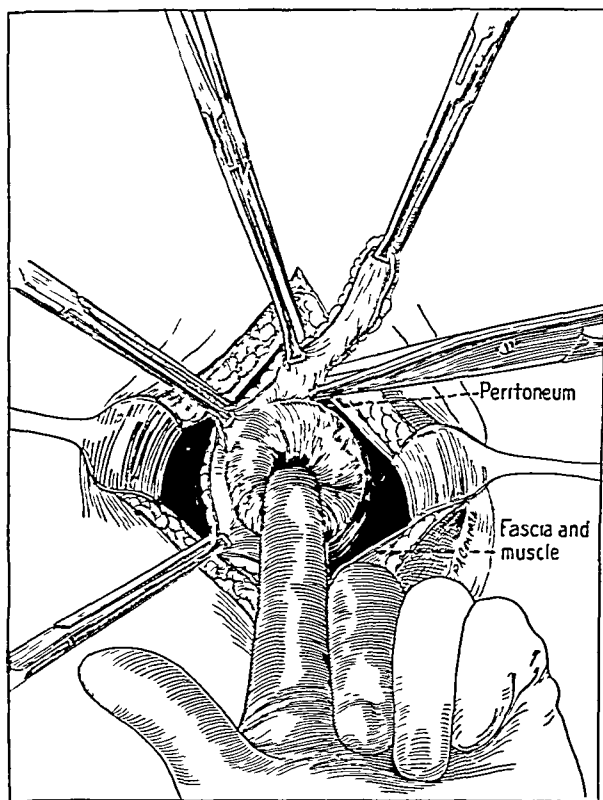


Fig 3—Skin and fat are trimmed from the bowel after mobilization down to the peritoneum

tion a 3/16 inch (0.48 cm) tenestrated flexible latex tube was fastened to the aforementioned string and passed up the rectum to just below the site of the colostomy if we happened to be dealing with one located in the sigmoid. A clamp was then fastened to the string about 6 inches (15 cm) from the opening in the bowel and the excess string cut away.

After suitable preparation of the skin the colostomy opening was circumcised, a narrow margin of skin being left attached to the bowel to provide points of counteraction for the dissection and also to avoid direct trauma to the margin of the bowel. When the fascia is reached, this structure should be incised for a distance of 1 inch (2.5 cm) both above and below the bowel, thus greatly facilitating the separation of fascia and muscle from the lateral and medial aspects of the colostomy. It was our custom to mobilize down to the peritoneum, which was not opened except occasionally as occurs unintentionally.

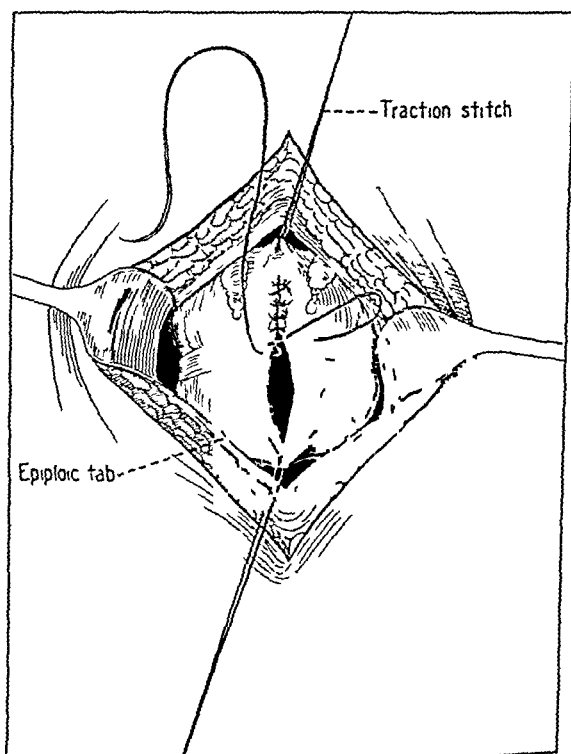


Fig 4—Transverse closure. The first row is done with a Connell continuous surgical gut mattress suture.

The margin of skin was then trimmed off, and, in the event we were dealing with a sigmoid colostomy, the small flexible rectal tube was threaded up the bowel 6 inches past the site of operation in order to act as a safety valve postoperatively. Transverse closure so as not to narrow the lumen was then carried out, a continuous Connell interrupted surgical gut suture being employed for the first row, followed by a row of interrupted fine silk mattress stitches. Epiploic fat tab

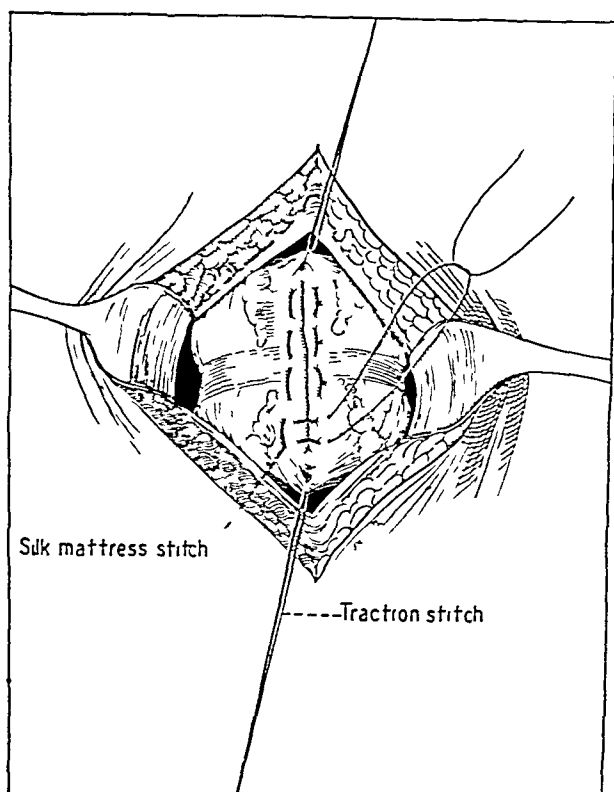


Fig 5—The second row is done with interrupted fine silk mattress sutures

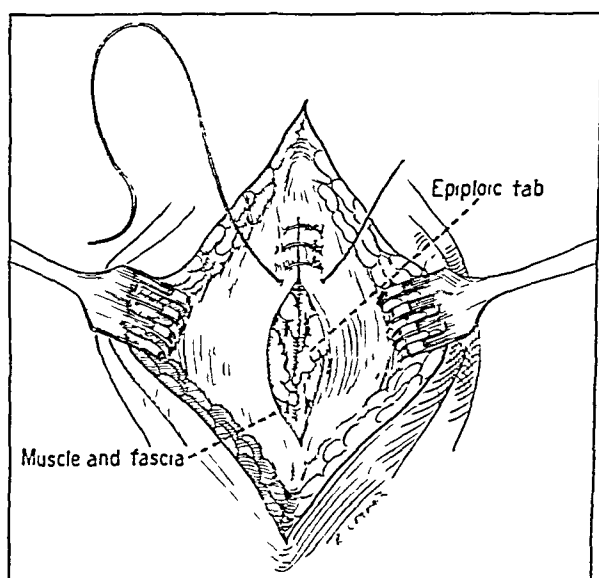


Fig 6—The epiploic fat tabs are tacked over the suture line. Closure of the fascia and muscle is done with chromic surgical gut.

present, were then tacked over the suture line. The fascia of the abdominal wall was closed with 00 chromic surgical gut, then a through and through fine Penrose drain was placed beneath the fat and brought out either angle of skin, after which silk was placed loosely in the skin.

For the cases in which there had been decided loss of bowel wall without creation of a double-barreled colostomy, intraperitoneal end to end anastomosis had to be performed.

Postoperatively we gave nothing by mouth for the first twenty-four hours, adequate intravenous alimentation being maintained meanwhile.

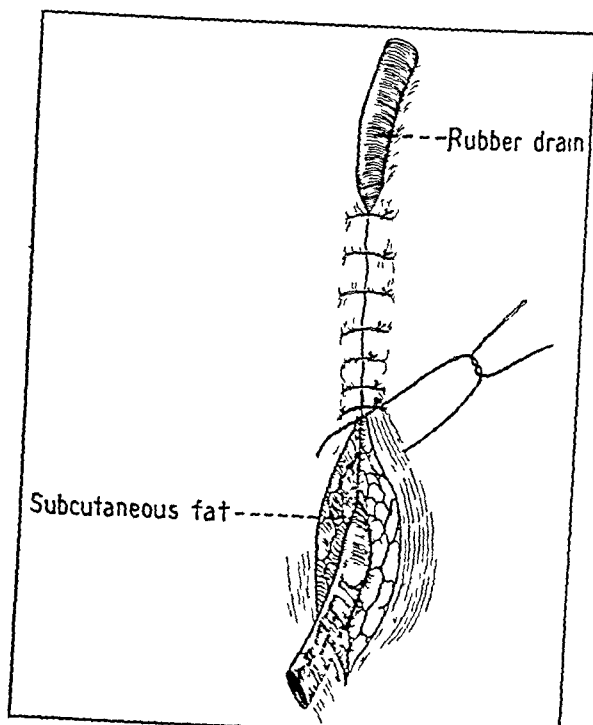


Fig 7—Subcutaneous through and through small Penrose drain

Following this nonresidue liquids were permitted for the first week and then a low residue soft diet the second week. The tube, which is sufficiently small and flexible to cause little irritation of the anus, was removed about the fifth day, administration of liquid petrolatum, 1 ounce (16 Gm) three times a day, having been started the previous day.

Failures to obtain closure of the colostomy should be and have been few in our series. One surgeon on our staff had two or three failures before it was noted that he was dissecting the wall of the bowel in the surrounding tissues without first circumcising the skin at the stoma.

It is thought that, following suture, leakage occurred through the traumatized and devitalized margins of bowel, for no further trouble was encountered after this practice was corrected

Colostomy Closures in Fifteenth Hospital Center from June 1944 to March 1945

Hospital	Colostomies Closed	Simple Trans verse Closure of Loop or Mikulicz After Spur Crushing	End to End Anastomosis	Postoperative Deaths
61st General Hospital	20	19	1	1
110th General Hospital	31	31	0	0
188th General Hospital	25	23	2	0
111th General Hospital	44	43	1	0
102nd General Hospital	60	40	20	0
186th General Hospital	25	18	10	0
67th General Hospital	12	12	0	0
104th Station Hospital	20	20	0	0
106th Station Hospital	20	27	3	0
91st General Hospital	20	0	23	0
Totals	298	238	60	1

SUMMARY

In summary it should be noted that in time of war injuries to the large bowel are complicated in a high percentage of cases by other major injuries, and it must be understood that the treatment must be fairly well standardized in order for the best over-all results to be obtained. Before closure is attempted care must be taken that colostomy spurs are adequately obliterated and that edema of the bowel and active infection of the wound are no longer present. Many closures can be kept extraperitoneal. In the case of closure of sigmoid colostomies we have employed a medium caliber latex rectal tube as a safety valve above the suture line and feel that this procedure has definite merit. Subcutaneous drains were placed in most closure wounds for forty-eight hours postoperatively, since these are contaminated wounds. Penicillin and sulfadiazine in standard doses were used in perhaps half of these cases. The value of succinylsulfathiazole as a bacteriostatic agent in the intestinal tract is well established, and its employment should be routine. Healing of the colostomies following closure was satisfactory in the large majority of instances, and there was only 1 postoperative death in 298 cases. This result is best explained by the fact that we were dealing with vigorous young men undergoing elective operation for whom were available unlimited supplies of such essentials as blood, plasma and chemotherapeutic agents for most thorough preoperative and postoperative treatment.

ABSTRACT OF DISCUSSION

CHARLES W. MAYO, M.D., Rochester, Minn. Dr. Bartlett's paper recalls the tribute due the physicians who were in the forward areas and whose primary management of traumatic injuries of the abdominal portion of the colon and of the rectum preserved so many lives and also the tribute due the Surgeon General from whose office emanated the directives regarding the treatment of these injuries.

Surgeons, in general, are divided into two groups regarding closure of a colonic stoma, namely, those who prefer the intraperitoneal type of closure and those who prefer the extraperitoneal type of closure. As a rule I believe that the mortality rate will be lower and the morbidity perhaps higher when the extraperitoneal method of reestablishing continuity of the colon is used than when the intraperitoneal method is used.

There are many details in the accomplishment of either method that must be observed for satisfactory results. Among them are the following steps: 1. The spur must be cut through adequately so that free passage of intestinal content will result. 2. Sufficient time to allow subsidence of edema and inflammation must elapse which varies in each case. 3. Fascia and muscle should be closed over the line of suture in the colon, and subcutaneous tissue and skin should be closed loosely or, perhaps preferably, by a secondary procedure about forty-eight hours later.

Not any one type of spur-crushing clamp will be satisfactory in all cases. One should have as many shapes and sizes of these clamps as one has scoops for exploration of the common duct. Several applications of clamps may be necessary, the main idea being not to attempt closure until the opening is adequate or a bit more than adequate.

The results of closure as reported by Dr. Bartlett for the Fifteenth Hospital Center are excellent. Extraperitoneal closure is safest, one can always repair a ventral hernia later on a live patient.

A MODIFIED TECHNIC FOR TOTAL GASTRECTOMY

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SURGICAL history records that Phineas Conner,¹ of Cincinnati, did the first complete gastrectomy on a human being in 1884. His patient died on the operating table before the operation could be completed. Thirteen years later, in 1897, Schlatter,² of Switzerland, successfully removed the stomach completely, and his patient survived one year and fifty-three days. In a discussion of Schlatter's case at a meeting of the *Deutsche Gesellschaft für Chirurgie* in 1898, Kronlein defined total gastrectomy as complete removal of the stomach with both the pylorus and the cardia and stated that, when examined, the specimen should show a portion of the duodenum at one end and a portion of the esophagus at the other. In a study of all total gastrectomies up to 1929, Finney and Rienhoff³ emphasized the importance of Kronlein's definition, since they found that more than half of the operations recorded as total gastrectomies were really partial gastrectomies.

The technic used for complete removal of the stomach and restoration of the continuity of the alimentary tract has shown many variations since the successful gastrectomy of Schlatter (figs 1 and 2). It is interesting to note that Schlatter's anastomosis between the esophagus and small intestine was an esophagojejunostomy. Since then many esophagoduodenostomies have been done, with and without the Murphy button. In recent years the operation of choice has been the esophagojejunostomy. A loop of jejunum has been placed either anterior or posterior to the colon.

Opinion has been divided concerning the value of a jejunojejunostomy between the ascending and descending portions of the jejunum below the jejunal anastomosis to the esophagus. There is some reason to doubt that an anastomosis between the two segments of the jejunal

From the Department of Surgery, University of Kansas Hospitals.

Presented at the meeting of the Western Surgical Association in Memphis, Tenn., Dec. 6, 1946.

1. Conner, P. S. Report of a Case of Complete Resection of the Stomach. *N. Y. News*, New York, 45:578, 1884.

2. Schlatter, C. A Unique Case of Complete Removal of the Stomach. Successful Oesophagoenterostomy. *Recovery*, M. Rec. 52:909, 1897.

3. Finney, J. M. T. and Rienhoff, W. F. J. Gastrectomy. *Arch. Surg.* 18:140 (Jan.) 1929.

loop will drain much of the content of the portion of the jejunum proximal to the esophageal stoma

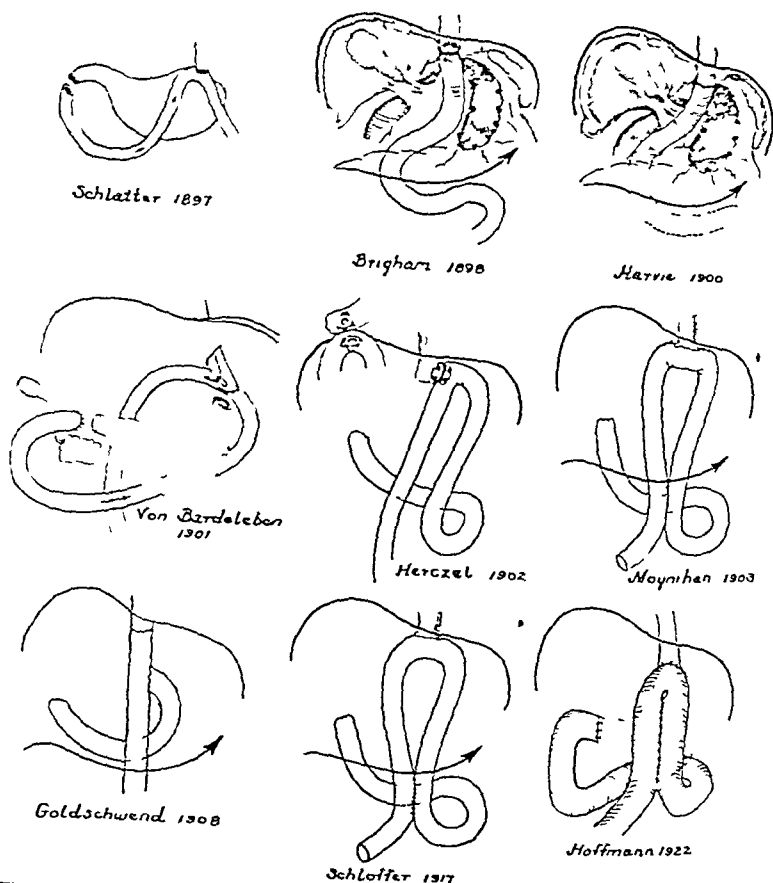


Fig 1—Sketches of the various methods used in the development of the technique of total gastrectomy.⁴

⁴ Brigham C B Case of Removal of the Entire Stomach for Carcinoma Boston M. & S. J. **138** 415, 1898 Harvie, J B Report of a Case Recovery After Gastrectomy for Carcinoma Ann Surg **31** 344, 1900 Von Bardeleben A Zur Kasuistik der totalen Magenextirpation Deutsche med Wchnschr **27** 330, 1901 Herczel, E V Beitrag zur totalen Exstirpation des carcinomatösen Magens, Beitr z klin Chir **34** 336 1902 Moynihan, B G A On Total Extirpation of the Stomach with a Record of an Unsuccessful Case, Brit. M. J. **2** 1458, 1903 Goldschwend, F Operations- und Dauererfolge bei maligner Geschwulstbildung Magens, Arch f klin Chir **88** 218 1908 Schloffer Resektion des ganzen Magens, Deutsche med Wchnschr **43** 1216 1917 Hoffman V Eine Methode des "plastischen Magenersatzes," Zentralbl f Chir **49** 1477, 1922 Schlatter²

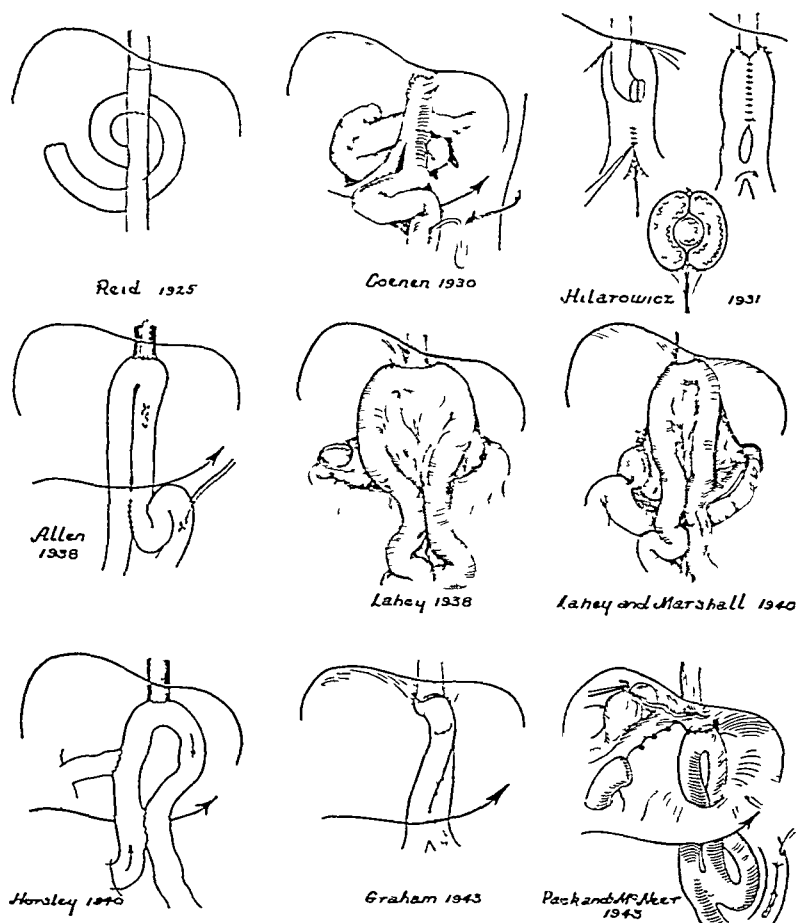


Fig 2—Sketches of various methods used in the development of the technique of total gastrectomy.

5 (a) Reid, M R Total Gastrectomy, *Surg Gynec. & Obst.* **41** 667, 1925 (b) Coenen, H Zur Methodik der Totalexstirpation des Magens, *Deutsche Ztschr f Chir* **225** 391, 1930 (c) Hilarowicz, H Zur Technik der totalen Magenextirpation, *Zentralbl f Chir* **58** 2613 1931 (d) Allen, A W Carcinoma of the Stomach with Special Reference to Total Gastrectomy, *Ann. Surg* **107** 770 1938 (e) Lahey F H Complete Removal of the Stomach for Malignancy Report of Five Surgically Successful Cases *Surg, Gynec. & Obst.* **67** 212, 1938 (f) Lahey, F H and Marshall, S F Indications for, and Experience with Total Gastrectomy, *Ann Surg* **119** 300, 1944 (g) Horsley, J S *Operative Surgery*, St. Louis, C V Mosby Company, 1940 vol 2, p 1032 (h) Graham, R R Total Gastrectomy for Carcinoma of the Stomach, *Arch Surg* **46** 907 (June) 1943 (i) Pack, G T and McNeer G Total Gastrectomy for Cancer, *Internat. Abstr Surg* **77** 265, 1943

DESCRIPTION OF MODIFIED TECHNIC

The stomach is emptied by an indwelling suction tube. A left paramedian incision is made from the angle between the ensiform and costal margin to a point 4 to 6 cm below the level of the umbilicus. This incision has furnished adequate exposure in all cases. After the decision has been made to remove the entire stomach the cardiac end of the stomach is exposed and peritoneal flaps are constructed and reflected upward from the anterior and posterior surfaces of the lower end of the esophagus. These peritoneal flaps are made first to insure adequate length of esophagus below the diaphragm for anastomosis and to explore for extension of tumor or metastases in this region.

To increase exposure of the esophagus the left hepatic ligament is severed and sutured beneath the right side of the abdominal wall.



Fig 3—Technic of total gastrectomy. The insert shows the type of paramedian incision used. The ligament of the left lobe of the liver has been severed and sutured beneath the right side of the abdominal wall to retract the left lobe. An incision has been made for the formation of peritoneal flaps and exposure of the esophagus.

to displace the left lobe of the liver to the right (fig 3). The duodenum is next freed and divided between clamps near the pylorus. The pyloric end of the duodenum is covered with gauze to prevent soiling. The distal end of the duodenum is closed with two rows of chronic surgical gut sutures reinforced with Lembert sutures of silk. The pyloric end of the stomach being used for traction, the gastrohepatic ligament is divided as far away from the stomach as possible, and vessels are ligated as the dissection proceeds. The omentum is completely removed with the gastrocolic ligament. When the spleen is approached the splenic vessels are ligated as near the spleen as possible. The spleen should be removed with the stomach if there is any infiltration of tumor tissue.

along the vessels or if troublesome hemorrhage is encountered (The spleen has not been removed in any of the 5 cases here recorded in the table) By retraction of the stomach upward over the margin of the wound the vessels near the cardia are easily exposed severed and

Summary of Five Cases of Total Gastrectomy

Patient	Sex	Age Yr	Date of Operation	Type of Operation	Pathologic Change	Length of Life to Dec 1 1946
E S	Female	64	1/27/46	Postcolic	Reticulum cell sarcoma	Alive 10 mo
A G	Male	60	7/11/46	Postcolic	Reticulum cell sarcoma	Alive 4½ mo
E G	Male	60	7/16/46	Antecolic	Adenocarcinoma	Alive 4½ mo
F P	Male	74	8/22/46	Antecolic	Adenocarcinoma	Alive 3½ mo
J B	Male	76	10/ 2/46	Postcolic	Colloid carcinoma	Died on 40th postoperative day hemiplegia and pneumonia

ligated. All areolar tissue is carefully dissected from the lower end of the esophagus, and the vagus nerves are severed to increase exposure. The esophagus is further freed and retracted downward by gentle, blunt



Fig 4—Technic of total gastrectomy (continued). The stomach and omentum have been freed and retracted. The insert shows the method of closing the duodenum with three rows of sutures.

finger dissection upward through the esophageal hiatus. From 5 to 8 cm. of the esophagus can usually be easily exposed below the diaphragm (fig 4).

The gastric suction tube is withdrawn into the esophagus, and a right-angled clamp is placed across the esophagus about 15 cm distal to the site chosen for the anastomosis. By placing the clamp transversely, the esophagus is flattened and widened near the suture line. This aids in the construction of as large a stoma as possible.

The jejunum is next divided between clamps about 15 cm below the ligament of Treitz. The proximal end is covered with gauze and held aside for later anastomosis. The distal end of the jejunum is closed with three rows of sutures. The distal segment is then drawn

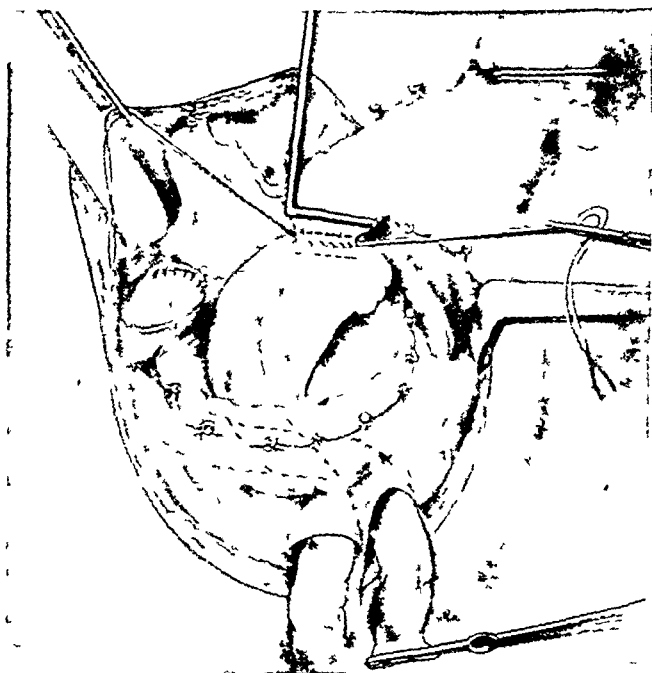


Fig. 5—Technic of total gastrectomy (continued). The jejunum is divided 15 cm. below the ligament of Treitz. The end of the distal portion of the jejunum is closed, and the first row of sutures and lines of incision are shown in the esophagus and jejunum as the first step in end to side esophagojejunostomy.

through an opening in the mesocolon or anterior to the colon and anastomosed to the esophagus 5 to 6 cm distal to its closed end. Interrupted silk stitches are used for the first row of sutures. A long suture is left at each end for traction. The esophagus and jejunum are then incised about 4 mm from the suture line, and a row of no. 00 chromic surgical gut lockstitch sutures is used to unite the full thickness of both esophageal and jejunal walls. As this suture is placed, traction is maintained on the tension sutures to enlarge the esophageal opening.

as much as possible. The anterior wall of the esophagus is next divided, and the stomach is removed. A surgical gut suture is used to unite the anterior margins of the esophagus and jejunum. An anterior row of silk Lembert sutures completes the anastomosis. The field is kept free from soiling by the right-angled clamp on the distal part of the esophagus, by constant suction through the tube in the esophagus and by suction in the wound (fig 5).



Fig 6—Technic of total gastrectomy (concluded). The end to side esophago-jejunoanastomosis is completed, showing peritoneal flaps sutured to the jejunum over the anastomotic line of suture. Lateral sutures have been placed to fix and suspend the jejunum. Postcolic end to side jejunojejunostomy is completed. The mesentery of the colon is sutured to the jejunum and the mesentery of the jejunum to close the defect in the mesocolon.

The line of anastomosis is covered, both anteriorly and posteriorly, with the previously constructed flaps of peritoneum. Finally, the jejunum is sutured to the diaphragm on each side of the anastomosis with two or three interrupted silk sutures to suspend the jejunum and decrease the tension on the anastomosis. When the anastomosis is completed the tube in the esophagus is passed into the jejunum. The suture in the left hepatic ligament is removed to release the left lobe of the liver.

An end to side anastomosis is made between the proximal end of the jejunum and the distal jejunum below the mesocolon. The margins of the incised mesocolon are sutured to the jejunum and its mesentery (fig 6).

The abdominal wound in all cases has been closed with stainless steel wire and silk. The abdomen is drained through the upper end of the incision. The tube is left in the jejunum for four or five days. Small quantities of water are injected through the tube after the first day. Suction is continued as long as the tube is in the jejunum. When the tube is removed liquid feedings are begun, and they are given several times daily. After ten days semisolid food is given in five or six feedings each day.

The postoperative progress in 4 of the cases here recorded was uneventful (table). In the fifth, and last patient hemiplegia developed four days following operation, which probably was responsible for his death, on the fortieth postoperative day.

COMMENT

The advantages of the technic described are (1) direct entrance of food into the jejunum distal to the anastomosis without filling of the proximal part of the jejunum as in the loop operation, (2) elimination of distention or delay in emptying of the proximal portion of a loop and (3) elimination of any regurgitation of the duodenal contents into the esophagus.

The mortality rate of total gastrectomy has been steadily decreasing since the first operation by Conner sixty-two years ago. The operative death rate recorded in 1929 by Finney and Rienhoff³ in a collected series of sixty-two undoubted total gastrectomies was 53.8 per cent. In 1943 Pack and McNeer⁴ collected 303 cases of total gastrectomy, with an operative mortality of 36.9 per cent. Eight consecutive cases of total gastrectomy were reported by Jones and Kehm⁶ in 1945 without a death, and in 1946 Moreland⁷ added 6 consecutive cases without a death.

With constantly improving methods of supportive treatment for patients submitted to surgical procedures and improvement and standardization of technic, it seems reasonable to predict that the mortality rate for total gastrectomy in the future will not exceed 10 to 15 per cent.

6 Jones, T. E. and Kehm, R. W. Total Gastrectomy, Surg. Gynec. & Obst. 80: 534, 1945.

7 Moreland, R. B. Total Gastrectomy, Arch. Surg. 52: 603 (May) 1946.

RUPTURED INTERVERTEBRAL DISK IN THE CERVICAL REGION

A Report of Twenty Cases

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AND

GUY L. ODOM, M.D.

DURHAM, N. C.

IT IS THE purpose of this paper to discuss briefly the diagnosis of the ruptured intervertebral disk in the cervical region and to correlate the clinical aspects of the syndrome with the pathologic-anatomic changes responsible. It is hoped that the report of this series of cases may contribute in some measure to the excellent reports that have been published about this clinical entity.

The ruptured cervical disk as a neurosurgical problem is nothing new, and there are numerous articles dating as far back as 1928 that deal with the ailment. In Stookey's work¹ the gross anatomic foundation of the clinical syndrome is clearly explained. His division into three clinical varieties based on the location of the intraspinal mass not only simplifies the conception of the condition but seems the only rational way of classification.

Stookey's group of 7 cases includes 6 cases of cord compression of one or both hemicolumns of the spinal cord or cord compression and what was interpreted as a lesion of the anterior horn accompanied with pressure on the long spinal tracts. Only 1 case was purely that of root compression and presented as such. Michelsen and Mixer² reported 8 cases, of which 1 was a case of cord compression and 7 were instances of root compression. Semmes and Murphy,³ Spurling and Scoville⁴

From the Neurosurgical Division, Department of Surgery, Duke University School of Medicine.

1 Stookey, B. Compression of the Spinal Cord Due to Extradural Cervical Chordomas. *Arch. Neurol. & Psychiat.* **20**: 275 (Aug.) 1928.

2 Michelsen, J. J. and Mixer, W. J. Pain and Disability of Shoulder and Arm Due to Herniation of the Nucleus Pulposus of Cervical Intervertebral Disks. *New England J. Med.* **231**: 279 (Aug. 24) 1944.

3 Semmes, R. E. and Murphy, F. The Syndrome of Unilateral Rupture of the Sixth Cervical Disk. *J. A. M. A.* **121**: 1209 (April 10) 1943.

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TABLE 1—Cases of U.

Case	Disk Ruptured at	Sex Age Occupation	Duration of Symptoms	Character of Pain	Distribution of Pain	Distribution of Paresthesias	Distribution of Reflexes
1 I K S	5th cervical interspace	Woman 35 yr housewife	3 yr	Intermittent and stabbing aggravated by movement of head and neck	Lower part of neck left shoulder entire left arm down to wrist	Dorsal forearm hand mostly thumb and index finger	Extensor of thumb
2 C L M	5th cervical interspace	Man 39 yr lawyer	9 wk	Intermittent lancinating aggravated by extension and rotation of head	Lower part of neck left shoulder and radial aspect of entire arm including thumb and index finger	Radial side of left hand thumb and index finger	Extensor of thumb
3 W H W	5th cervical interspace	Man 52 yr laborer	2 mo	Intermittent shooting slightly affected by movement of head and neck	Left shoulder and radial side of arm to wrist	Thumb and index finger	Extensor of thumb
4 E P P	5th cervical interspace	Woman 32 yr housewife	3 yr	Intermittent lancinating aggravated by movements of head and neck	Lower part of neck left shoulder blade to posterior aspect of upper arm	Radial side of entire arm including radial side of left hand thumb index and long finger	Extensor of thumb
5 L R G	5th cervical interspace	Man 32 yr electrician	3 mo	Intermittent aggravated by movements of head and neck	Lower part of neck left shoulder and entire arm	Right arm and hand	Extensor of thumb
6 G L O	6th cervical interspace	Man 39 yr mechanic	3 mo	Intermittent lancinating aggravated by movements of head and neck	Lower part of neck left shoulder entire left arm 2d meta carpal bone	Same distribution as pain including all fingers but centered on index finger	Extensor of thumb
7 V D C	6th cervical interspace	Woman 39 yr housewife	1 yr	Intermittent lancinating aggravated by movements of head and neck	Lower part of neck right shoulder extension side of entire arm dorsum of hand index middle and ring fingers	Extension side of arm including index and long finger	Extensor of thumb
8 V L T	6th cervical interspace	Man 39 yr salesman	1 yr	Intermittent lancinating aggravated by movements of head and neck	Lower part of neck and entire left arm	Left hand	Extensor of thumb
9 H F S	6th cervical interspace	Man 51 yr physician	6 yr	Intermittent shooting aggravated by movements of head and neck	Lower part of neck right shoulder extension side of upper arm to elbow	Extensor side of forearm thumb and index finger	Extensor of thumb
10 T G H	6th cervical interspace	Woman 39 yr	5 wk	Intermittent shooting aggravated by movements of head and neck	Lower part of neck right shoulder extension side of entire arm	Extensor side of arm and hand centered in index and middle fingers	Extensor of thumb
11 M R L	6th cervical interspace	Man 56 yr business man	9 wk	Intermittent lancinating aggravated by movements of head and neck	Right shoulder extension side of entire arm to wrist	Thumb and index finger	Extensor of thumb
12 M E Y	6th cervical interspace	Woman 44 yr housewife	3 mo	Intermittent shooting aggravated by movements of head and neck	Lower part of neck left shoulder extension side of entire arm to index middle and ring fingers	Same distribution as pain	Extensor of thumb
13 E F E	6th cervical interspace	Man 36 yr painter	11 wk	Constant but aggravated by movements of head and neck	Lower part of neck left shoulder extension side of arm to midforearm	None	Extensor of thumb
14 L S S	6th cervical interspace	Man 47 yr druggist	3 mo	Intermittent lancinating aggravated by movements of head and neck	Right shoulder extension side of arm to midforearm	Dorsum of hand centered on 2d metacarpal bone	Extensor of thumb
15 S H	6th cervical interspace	Woman	6 wk	Constant boring aggravated by movements of head and neck	Left shoulder extension side of entire arm down to wrist	None	Extensor of thumb
16 G M	6th cervical interspace	Man 52 yr laborer	6 wk	Severe shooting not aggravated by movements of head and neck	Left shoulder blade extension side of upper arm toward wrist	Left index finger	Extensor of thumb

Sensory mpairment	Muscles Involved	Tendon Reflexes		Other Findings	Referring Physician	
		Right	Left			
ul side of fore- including thumb st intermeta ul space	Biceps and deltoid disuse atrophy of left shoulder girdle and left arm	Bicep Triceps Radial	++ ++ ++	---	Remaining neurologic examination normal	Dr L Provancha Jacksonville, Fla
ul side of fore and hand	Deltoid triceps brachio radialis and extensors of wrist	Biceps Trice p Radial	+++ +++ +++	---	Remaining neurologic examination normal	Dr N C Wolfe Burgaw N C
ul side of hand ding thumb and finger	Deltoid	Bice p Trice p Radial			Neurologic examina tion not satisfactory	Dr F I Jordan Greenville, S C
ul side of fore and hand, includ thumb	Deltoid biceps triceps and extensors of hand and fingers	Bicep Triceps Radial	++ ++ --	==	The ruptured disk ex erted pressure on the sixth cervical root and to a much less degree on the seventh cervical root be cause of Arnold Chiari mal formation in this patient	Dr E M Hedgepath Chapel Hill, N C
neor side of arm hand	Generalized weakness of right arm	Biceps Tricep Radial	== -- --	---	Remaining neurologic examination normal	Dr G C Axelson Martinsville Va
neor side of arm including intermetacarpal e	Triceps biceps deltoid and pronators of hand	Biceps Triceps Radial	++ ++ --	--	Remaining neurologic examination normal	Dr J T Saunders Asheville N C
neor side of entire dorsum of hand o 4th intermeta al spaces 1st to fingers	Rhomboids serratus anterior triceps ex tensors of wrist and deltoid	Bicep Triceps Radial	++ ++ ++	---	Remaining neurologic examination normal	Dr S R Johnson Dunn N C
e	Triceps and deltoid	Bicep Triceps Radial	++ ++ --	---	Remaining neurologic examination normal	Dr E T West Johnson City Tenn
e	None	Biceps Triceps Radial	++ -- +	---	Remaining neurologic examination normal	Dr H F Starr Greensboro N C
row hand over re extensor side of and hand includ index and middle ers	Rhomboids triceps latissimus dorsi and biceps	Biceps Triceps Radial	++ ++ ++	---	Remaining neurologic examination normal	None
e	Triceps latissimus dorsi serratus anterior deltoid and biceps	Bicep Tricep Radial	++ -- +	---	Remaining neurologic examination normal	Dr E M Hedgepath Chapel Hill N C
ensor side of re arm dorsum of d and fingers	Triceps serratus an terior and extensors of hand	Bicep Triceps Radial	++ ++ +	++	Remaining neurologic examination normal	Dr R M Whitley Rocky Mount N C
ree middle fingers	Triceps serratus an terior and deltoid biceps	Biceps Triceps Radial	++ ++ ++	++	Remaining neurologic examination normal	Dr J R Latham New Bern N C
lial aspect of dor of hand not luding fingers	Triceps	Biceps Triceps Radial	++ ++ ++	++	Remaining neurologic examination normal	None
tensor side of re arm radial side hand		Bicep Triceps Radial	++ ++ ++	++	Remaining neurologic examination normal	Dr F M He Durham N C
ft index finger	Tricep selective disuse atrophy of left arm	Biceps Triceps Radial	++ ++ ++	++	Rema n ng neurolog c examination normal	Dr V J Cox Galax Va

and Bucy⁵ all reported cases of pure root compression by a ruptured cervical disk. In the present series of 20 cases there are 16 of root compression (table 1) and 4 of cord compression (table 2).

In a review of the histories of the cases of Stookey's patients, it was observed that in 5 of the 6 cases of cord compression the condition began

TABLE 2—Cases of Cord

Case	Disk Ruptured at	Sex, Age and Profession	Duration of Symptoms	Distribution of Pain	Distribution of Paralysis	Sensory Impairment
17 Y. E.	5th cervical interspace, left side	Man 40 yr school principal	3 mo	Ulnar side of forearm 3d, 4th and 5th fingers left	Ulnar side of forearm 3d, 4th and 5th fingers left	Analgesia below third thoracic dermatome on right hypoesthesia below third thoracic dermatome on left position sense normal in toes
18 M. G. H.	7th cervical interspace transverse	Woman 32 yr housewife	5 mo	No pain recorded	Posterior surface of legs, soles	Dissociated sensory impairment below sixth thoracic dermatome bilaterally position sense impaired in feet
19 L. M. G. B.	5th cervical interspace transverse	Woman 31 yr housewife	2 yr	No pain recorded	Right hand and foot left hand and foot	Slight impairment to feet (20-30 decibel) below elbow and knee bilaterally position sense lost in toes on right
20 H. T.	5th cervical interspace transverse	Man 43 yr farmer	6 mo	Left shoulder and arm	Left hand and left lower limb	Vibration sense to fork (25 decibel) lost in hand bilaterally to fork (20 decibel) lost in feet bilaterally position sense lost in fingers, toes pain and temperature intact

with subjective complaints of pain in the arm and shoulder preceding paraparesis for a variable length of time. In Michelson's and Minter's case cord compression began with pain in the shoulder and arm twenty-three years before the onset of paraparesis. In 2 of our 4 cases of cord compression the syndrome began with pain in the neck and shoulder

⁵ Bucy, P. C. and Chenault, H. Compression of Seventh Cervical Nerve Root by Herniation of Intervertebral Disk. *J. A. M. A.* 126:26 (Sept. 2) 1944.

before the onset of paraparesis. These facts show a discrepancy of 7.1 in the proportion of root and cord compression in Michelsen and Mixer's series² as compared with 16.4 in the present group and 1.6 in that of Stookey,¹ the earliest reported series. This discrepancy is strongly suggestive of an earlier recognition in the more recent reports.

d Root Compression

Muscle Weakness	Cervicourinary Function	Reflexes		Other Findings	Referring Physician
			Right Left		
muscles of left hand weakness of left thumb	Impaired	Biceps	---	---	Dr W E Cook Mebane N C
		Triceps	---	---	
		Radial	---	---	
		Abdominal	0 0		
			0 0		
		Knee jerk	---	---	
		Ankle jerk	---	---	
		Plantar	↓	↑	
weakness of both lower	Unimpaired	Biceps	---	---	Dr J C Shuler Durham N C
		Triceps	---	---	
		Radial	---	---	
		Abdominal	0 0		
			0 0		
		Knee jerk	++++	----	
		Ankle jerk	---	---	
		Plantar	↑	↑	
general weakness of arm and hand moderate weakness of left hand no definite general weak- ness of both lower limbs	Unimpaired	Biceps	---	---	Dr C Ewell Rocky Mount N C
		Triceps	---	---	
		Radial	---	---	
		Abdominal	0 0		
			0 0		
		Knee jerk	----	----	
		Ankle jerk	---	---	
		Plantar	↑	↑	
atrophy and weakness of shoulder girdles and more so on left moderate weakness of both lower limbs more so on left	Unimpaired	Biceps	-	+-	Horner's syndrome on left side Dr R G Tyndall Kinston N C
		Triceps	-	---	
		Radial	-	---	
		Abdominal	0 0		
			0 0		
		Knee jerk	----	----	
		Ankle jerk	+-	++	
		Plantar	↑	↑	
		Hoffmann	0	-	

The differences between the cervical and the lumbar portion of the spinal canal—and particularly the difference between the contents of these two most mobile sections of the canal—are those of dimensions and anatomic function. The cervical canal contains the cervical nerve roots and the cervical cord, whereas the lumbar canal contains the cauda equina and no spinal cord below the first lumbar vertebra. In the cervical canal, within the dural sheath, the cord is anchored by the

dentate ligament on both sides and the nerve roots pass through their intervertebral foramina almost instantly after exit from the cord. Because of these characters the neural structures are relatively immobile. When one considers that the relation between the cervical interspaces and their corresponding nerve roots is a much closer one than is the case in the lumbar portion, it becomes evident that root compression in the cervical canal will occur with much greater localization than that in the lumbar portion. Though the cervical intervertebral disks and, therefore, the disk protrusions also are much smaller than those in the lumbar region, it is nevertheless justifiable to say that the potentiality for compression of a nerve root is much greater in the cervical region.

The relative immobility of the cervical neural structures explains the rapidity of onset of symptoms and signs and why the actually small but relatively large protrusions of the ruptured disk may result in selective pressure on one hemilateral or even hemianterolateral column only. The localization of unilateral compression of a single root in the cervical part of the spine due to the close relation of interspace and corresponding nerve root is, however, slightly altered in a few instances when a single protrusion exerts pressure on two adjacent nerve roots. This will be encountered in patients with Arnold-Chiari malformation, in which the disproportion of growth of spinal cord and spinal column will result in a parallel, longitudinal passage of the cervical roots for a short distance (case 4). Arnold-Chiari ailment is not common, however, and such a coincidence will be a rarity.

In the lumbar canal the two main reasons for compression of multiple roots are (1) multiple ruptured disks and (2) large protrusions that extend medially. In the cervical portion of the spine multiple ruptures are possible for the same reasons as in the lumbar part of the spine, namely, because of the extensive movements and relatively poor support of this part of the spine. The small series of cases reported here, however, does not include such an instance.

Large protrusions in the cervical region will cause compression of the spinal cord. The resulting syndrome, dominated by signs related to the cord, will lead to a diagnosis of a lesion in the cord that may be misleading as to the causation. At the time of rupture a large protrusion may occur suddenly and compress the cord instantly. The syndrome will then begin and remain as that of a lesion of the cord, and thus it is logical to distinguish between cord compression and root compression resulting from a ruptured cervical disk. There are, however, reasons to assume that in several instances these two varieties mark successive stages in the pathogenesis of a ruptured cervical disk and that the pathogenesis at times should be divided into three periods: (1) period of root compression, (2) period of unilateral cord compression with or without masked root compression, and (3) period of bilateral cord compression with masked unilateral or bilateral root compression.

The most vulnerable point in the annulus fibrosus and posterior longitudinal ligament is, as in the lumbar portion of the spine, situated laterally in relation to the spinal canal or anterior to the corresponding nerve root and not the spinal cord itself. Therefore, in the majority of cases compression of the root will occur first and the outstanding com-

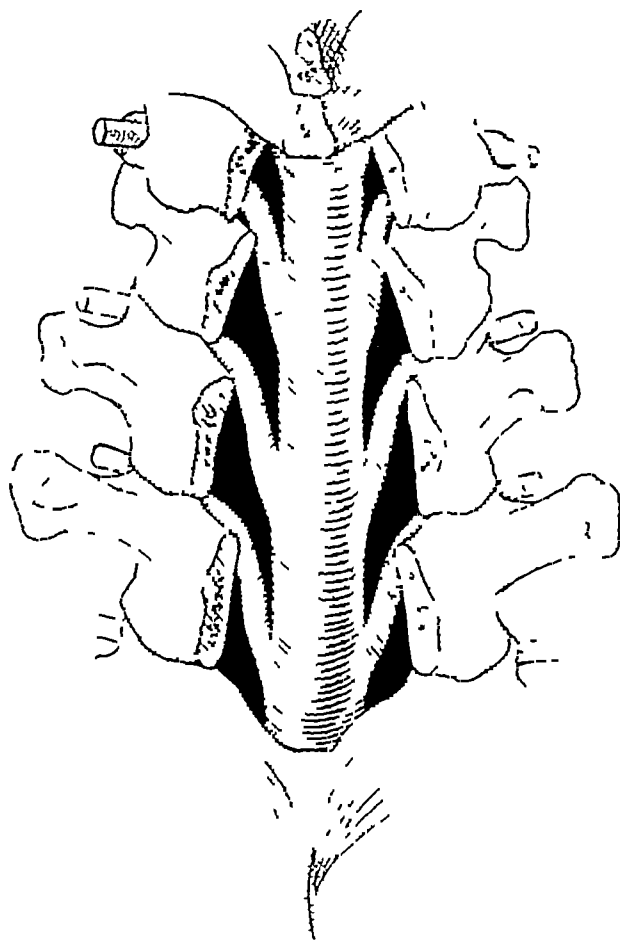


Fig 1—Drawing of the cervical canal, containing the cervical nerve roots and cervical cord showing relations of roots and cord in a case of Arnold-Chiari malformation

plaint will be radicular pain and paresthesias referable to the dermatome of that root.⁶ The dominating neuropathologic signs, if present, will also be referable to the peripheral distribution of that same root. It will be

⁶ Foerster, O. The Dermatomes in Man, *Brain* 56:1 (March) 1933

possible to exclude a lesion of the cord by the absence of ipsilateral signs in the pyramidal tract and contralateral spinothalamic signs. Certain movements of the head and neck will reproduce the radicular pain and paresthesias, and, consequently, this along with the absence of tenderness of the nerves and muscles will rule out the possibility of a lesion of the peripheral nerves.

This stage of root compression may not advance any further, and the syndrome may remain as such, with remissions and exacerbations for years.

LATERAL PROTRUSIONS WITH ROOT COMPRESSION UNCOMPLICATED BY CORD COMPRESSION

The cases of lateral protrusions with root compression are summarized in table 1. Experience reveals that rupture of an intervertebral cervical disk takes place at the fifth and sixth interspaces in most of the cases. This is probably due to the greater mobility of these joints and

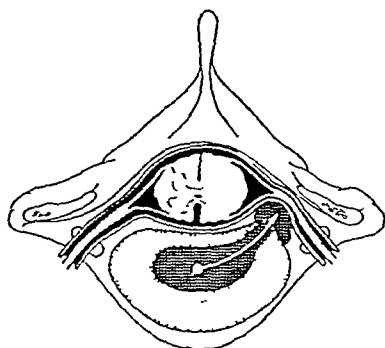


Fig 2—Uncomplicated root compression as a result of a ruptured disk.

is comparable to the common lesion in the fourth and fifth interspaces in the lumbar portion of the spine. This does not mean, however, that ruptures are confined to these interspaces, as may be seen in the tables. Nevertheless, they are the commonest sites of rupture, and the syndromes arising are now so well known that the diagnosis of a ruptured disk at one of the two aforementioned interspaces can be made clinically with great certainty as long as the result of the rupture is an uncomplicated root compression (fig 2).

In all probability all ruptures of intervertebral cervical disks are traumatic in origin, but it is not always possible to obtain a history of trauma. A long time may have elapsed since the initial injury, and the patients may have forgotten or, as frequently is the case, they simply have not been asked about such an initial injury. Further, the injury may have been so mild that the patient failed to connect it with the pain

in the shoulder and arm later developing. By careful questioning, a history of an initiating trauma will be obtainable in nearly all cases.

The subjective complaints are almost invariably those of pain in the lower part of the neck that soon afterward is overshadowed by complaints of pain radiating from the neck to the shoulder and arm accompanied with paresthesias in a more distal area. The radicular pain will differ both in distribution and in extent; it will at times involve only the shoulder and upper arm but it may extend to the fingers. The distribution will vary and the pain may be referred to the supraclavicular fossa, pectoral region, back of the shoulder, shoulder blade, radial side of arm and fingers, extensor side of the upper arm and forearm and other regions.

The paresthesias will be felt in the same distribution as the pain but usually will extend more distally than does the pain. For example, when the sixth cervical root is compressed the distribution of paresthesias will be the radial side of the forearm, thumb and index finger, whereas it will be the extensor side of forearm, dorsum of the hand and one or all of the three middle fingers when the seventh cervical root is compressed.

Both the pain and the paresthesias are nearly always aggravated by movements of the head and neck which result in direct compression of the nerve root. In most cases pain and paresthesias are brought on also by increased intraspinal pressure resulting from distention of the cervical rachidian veins.

The objective signs may be divided into mechanical defensive signs and neuropathologic signs. The former which act to protect against sudden compression of the nerve root are the tilted head and wry neck, the tenderness to manipulation of the lower cervical spinous processes (a procedure that frequently will reproduce the radicular pain), and last the most reliable sign of a ruptured cervical disk at the fifth and sixth interspaces, tenderness to hyperextension, flexion and lateral flexion of the head toward the side of pain, manipulations which seldom fail to call forth the patients' pain and paresthesias in all their extent.

The neuropathologic signs that may be associated with the mechanical defensive ones are indicative not only of root compression but also of the root compressed and are therefore localizing in character. They may not be observed for some time after the onset of pain and paresthesias. They consist of selective hypotonia and weakness and later fibrillations and atrophy of certain of the arm muscles, undissociated sensory impairment in certain dermatomes and last diminution or certain of the tendon reflexes of the arm. These neuropathologic signs are indicative of degeneration of the nerves and are of much graver significance than the neuropathologic complaints which only indicate irritation of the root. Both the subjective complaints and the defensive signs will disappear after removal of the ruptured disk, whether the neuropathologic signs do so or not will depend on the duration of root compression.

DIAGNOSIS

The diagnosis of the ruptured cervical disk is primarily clinical, and the history and subjective complaints are of the greatest aid in arriving at an early diagnosis. The ability to bring on the pain and paresthesias by manipulation of the lower cervical spinous processes and by hyperextending, flexing and laterally flexing the head toward the side of pain will confirm the presumptive diagnosis of a ruptured cervical disk. This will be possible with infrequent exceptions as long as the clinical syndrome is that of uncomplicated root compression. As will be seen in the tables, a ruptured disk at the fifth cervical interspace may be diagnosed when pain and paresthesias are referred to the radial side of the arm thumb and index finger, the sensory impairment, if present involves the same area or part of it, there is weakness, primarily of the deltoid and biceps muscles, and the biceps reflex is diminished.

In a like manner a rupture at the sixth cervical interspace may be diagnosed when the pain and paresthesias are referred to the extensor side of the arm, dorsum of the hand and one or all of the three middle fingers, the sensory impairment if present involves the same area or part of it, there is weakness primarily of the triceps muscle and the triceps reflex is diminished. This empiric division conforms fairly well with the segmental representation of current sensory and motor table.

Apparently the sensory areas supplied by the sixth and seventh cervical roots overlap somewhat, both in the anatomic arrangement and in the patient's interpretation. Therefore the examiner will have to approach the evaluation of the hypalgetic areas of the skin with a certain critical judgment. As to the involvement of muscles, the deltoid and biceps muscles seem to be earliest and most frequently affected when the sixth cervical root is compressed, and the triceps muscle is affected when the seventh is involved. Because of the complicated segmental representation of the muscles of the arm and shoulder, it is difficult to go any further in the evaluation of muscular weakness as a localizing sign. However, one will find the involvement of these three muscles reliable when weakness of the muscles is present.

ROENTGENOGRAMS OF THE BONY STRUCTURES

At times narrowing of the interspace in question may be seen in the roentgenogram in the lateral view. An unusually straight neck or absence of the physiologic cervical lordosis may be seen also in the same view. The oblique view may or may not show localized arthritic changes and narrowing of the intervertebral foramen in cases of lateral protrusion. In such instances these changes can be seen only on the one side necessitating oblique views of both sides for comparison.

These roentgenologic findings are positive evidence of a ruptured disk, but their absence by no means rules out the possibility of rupture.

of a disk. In cases of cord compression roentgenograms of the bony structures can furnish only negative evidence.

MYELOGRAPHY

Myelography is necessary in all cases of cord compression for diagnosis of the level involved. In instances of lateral protrusion and root compression it may be necessary to employ this valuable diagnostic method principally to prove the presence of a ruptured disk when other differential diagnostic ailments have been strongly suggested.

Myelography is an accurate method of diagnosis whether iodized poppyseed oil or Pantopaque (ethyliodophenylundecylate) is used as contrast medium. In cases of lateral protrusion the shadow of the contrast medium is often so characteristic that an etiologic diagnosis can be made from the roentgenograms alone. The defect in the shadow of the contrast medium is well rounded, occupies a lateral position over the interspace in question or, in cases of small protrusions, only hinders penetration of the contrast medium into the sleeve of the compressed root.

DIFFERENTIAL DIAGNOSIS

The pathologic conditions that usually cause difficulties in the recognition of a ruptured cervical disk with uncomplicated root compression will be discussed briefly.

1 *Cervical Arthritis*—Cervical arthritis, which is primarily an ailment of old age, is associated with pain in the neck aggravated by motion of the head and neck, and with diffuse tenderness to palpation of the cervical part of the spine. It may also result in radicular pain of distribution over the root. The local pain and tenderness are easily explained, the radicular pain is less so.

As in all conditions of diffuse arthritis of the spine the intervertebral disk has, to a greater or less extent, lost its dynamic capacity. The interspaces are narrowed and the usual irritative, hypertrophic spur formations occur at the edges of the bodies of the vertebrae. As a matter of fact these spurs will occur at the posterior lateral border of the bodies as well as on the anterior border and can affect the roots as they pass through the narrowed intervertebral foramina.

It is feasible to assume that in such cases irritation of the root is due to destruction or damage to the intervertebral disk even though the latter cannot be classified as a ruptured disk. The reports of calcified ruptured disks probably deal with cases of excessive hypertrophic arthritis of the cervical portion of the spine. The history however will be different since there will have been a long chronic course without initial trauma. The neurologic examination will as a rule fail to show the objective neuropathologic changes of root compression although the complaints will be those resulting from genuine irritation of the root. The

roentgenograms usually will show diffuse arthritic changes of the cervical and lumbar portions of the spine, if not the entire spine, and, frequently, narrowing of one or two of the intervertebral foramina. These findings, however, allow only the diagnosis of arthritis unless the abnormality is confined to only one interspace. Lumbar puncture, manometric readings and estimation of total protein contents will yield no decisive results, and myelography will show only evidence of the prominent posterior borders of the interspaces. If the subjective pain and paresthesias are sufficiently severe, the description will be accurate enough to allow localization and decompression of the affected root or roots.

2 Scalenus Anticus Syndrome—Scalenus anticus syndrome, which is divided into nervous and vascular varieties, will often be mentioned in differential diagnosis. The radiation of pain and paresthesias confined to the ulnar or ulnar-median distribution is customarily designated as the scalenus anticus syndrome. It has never been adequately explained why symptoms and signs from the first dorsal and eighth cervical nerve roots predominate over the signs from the seventh, sixth and fifth roots following compression of the brachial plexus where it passes between the scalenus medius and anticus muscles. It is possible, as suggested by Spurling⁴ that the scalenus anticus syndrome in its broadest sense is superimposed on a ruptured cervical disk and that it is based wholly on vascular changes due to compression of the subclavian artery. The radicular pain and the selective paresthesias, on the other hand, should be considered as the results of true root compression and not as due to compression of the plexus. In the present series the vascular signs and symptoms have not been listed in the tables, but that does not mean that they were not present. At any rate, it should be observed as a general rule that the scalenus anticus muscle should not be sectioned until myelography has been performed, the assumption being that the spasm of the muscles of the neck is a defensive sign and present only to prevent sudden pressure on a nerve root by a ruptured disk at the seventh cervical interspace.

3 Laminal Fractures in Cervical Region—Laminal fractures in the cervical region have a similar history to that of ruptured disk insofar as initial trauma and persistent radicular pain are concerned. Roentgenograms of the cervical part of the spine, particularly the oblique views, are of the greatest importance in these cases, as the laminal fragment may be seen protruding into the intervertebral foramen. The clinical picture is similar to that of a ruptured cervical disk and at times is indistinguishable until the lesion is exposed at operation.

4 Cervical Rib or Elongated Transverse Process of the Seventh Cervical Vertebra—Cervical rib or an elongated transverse process of the seventh cervical vertebra is often found accidentally on roentgenograms without any subjective or objective signs of involvement of the

nerves. It will at times cause pain and paresthesias of the shoulder and arm due to pressure on the plexus and artery, and accordingly that syndrome can be divided into a nervous and a vascular one. However, the course of such a disability will have been chronic and gradual and without remission and exacerbations. The pain will be aggravated by movements of or downward pull on the arm or other movements. The objective findings will be dominated by the vascular signs, that is, abolition of the radial pulse, difference in blood pressure in the two arms and difference in temperature of the arms and certainly the rib, if not palpable, will be seen in the roentgenograms. If the pain does not subside after removal of the rib, myelography should be performed.

5 *Subdeltoid and Subacromial Bursitis*—Subdeltoid and subacromial bursitis should cause only slight difficulties in differential diagnosis when the history is examined. There are local tenderness and limitation of movement in the shoulder joint, and roentgenograms of the shoulder may show the calcification.

6 *Brachial Neuritis*—Brachial neuritis gives pain in the entire arm which is diffuse and constant in nature and not aggravated by motion of the head and neck. There is exquisite tenderness to palpation along the course of the affected nerves and pronounced tenderness of the muscles, neither of which is present in root compression due to ruptured cervical disk.

7 *Pancost's Tumor*—Pancost's tumor may be mentioned as a rarity. It will give pain in the shoulder and axilla and eventually Horner's syndrome will develop. Roentgenograms of the chest will reveal a homogeneous shadow at the apex of the lung and thus disclose the true nature of this ailment.

8 *Cervical Radiculitis*—Cervical radiculitis, which is said to involve most commonly the sixth and seventh nerve roots, may be mentioned here. Root compression cannot be distinguished by any other means than myelography or exploration.

LARGE PROTRUSIONS WITH ROOT COMPRESSION COMPLICATED BY CORD COMPRESSION

If the protrusion occurs medially (fig 3A) or it as is clearly detectable in the histories in 9 of the 11 cases of cord compression reported, the protruding ruptured disk proceeds farther and turns over in the medial direction across the interspace and produces pressure on the ipsilateral half of the cord (fig 3B); the stage of unilateral cord compression is established. This is possible without much displacement of the cord so that transmitted pressure on the ipsilateral part of the

7 Stookey reported 6 cases of cord compression. Michelson and Mixer 1 case of cord compression and the present series 4 cases of cord compression.

posterior section of the column may not be present due to the fixation of the cord. In all likelihood the root compression is present nonetheless, but it will already be masked by signs related to the cord, which are signs in the ipsilateral pyramidal tract and contralateral spinothalamic signs with indefinite sensory level, several segments below the true lesion. The signs related to the root, weakness of the muscles and fibrillations and diminution of the tendon reflexes in the arm will be ascribed to a lesion in the anterior horn. It will no longer be possible not to suspect a tumor of the cord and to subject such a patient to myelography. The cases of root compression complicated by cord compression are summarized in table 2.

If myelography is not done and the diagnosis not made, in such a case unilateral cord compression will likely pass into the stage of bilateral cord compression by further expulsion of the fragment of the disk.

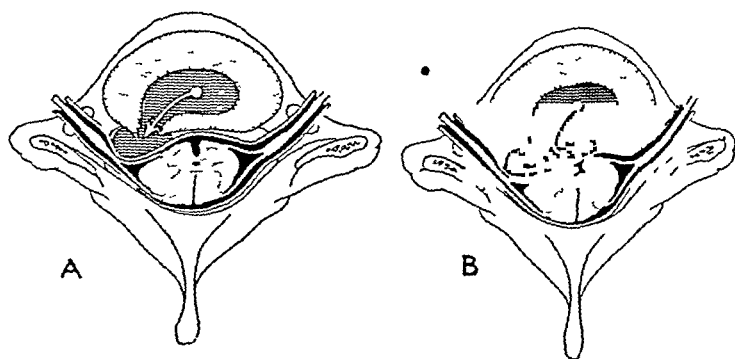


Fig 3—Root compression complicated by cord compression. A, medial protrusion with pressure of the disk on the ipsilateral half of the cord. B, large medial protrusion with pressure on both hemicolumns of the cord.

through the tear and further extension of it in medial direction. If so, the signs related to the root may no longer be recognizable as such. The sensory impairment in one or both upper extremities will be confined to the fingers and hand and easily interpreted as peripheral in nature. The unilateral or bilateral, disassociated or undisassociated sensory loss in the lower limbs may or may not extend up onto the trunk. The wasting and weakness in one or both upper extremities will be associated with spastic weakness of the lower limbs. Therefore, it is not surprising that such a syndrome is frequently diagnosed as due to syringomyelia or to an intramedullary tumor.

If there are signs from the posterior columns in addition to the others, a possible diagnosis of subacute combined degeneration will also be entertained in many of these cases. This is not at all unreasonable, since in the great majority of these cases a lumbar puncture will

reveal normal manometric readings on a Grant Cone test and the total protein content of the spinal fluid frequently within normal limits. Therefore, the true nature of the lesion probably will not be recognized until myelography has been performed.

The complaints during these two later stages are likely to be those of indefinite pain in the neck and one or both shoulders, but probably these often will be overshadowed by complaints of weakness in one or both lower limbs or even ataxia of the lower limbs.

DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The problems of diagnosis after compression of the cord or when compression has been present from the beginning are twofold, namely those of etiology and those of spinal level. If a history of trauma to the neck with transient radicular pain and paresthesias is obtained, even if it preceded the paraparesis by many years, it is highly probable that the cord compression is caused by a ruptured disk. Otherwise an etiologic diagnosis will not be made definitely until the lesion is exposed. The diagnostic procedures for the determination of the level of the lesion will be the same as those for a tumor of the spinal cord, and the condition to be considered in the differential diagnosis will be the same as those in the instance of tumors of the spinal cord.

LUMBAR PUNCTURES WITH MANOMETRIC READINGS AND ESTIMATION OF TOTAL PROTEIN CONTENT OF THE SPINAL FLUID

In cases of lateral protrusions, the manometric readings will be normal and the total protein levels of the spinal fluid within normal limits. In cases of large protrusions, the manometric readings often will be

TABLE 3—Results of Manometric Reading and Examination of Spinal Fluid for Total Protein Content

Case	Manometric Reading	Spinal Fluid Total Protein, Mg /100 Cc.	Case	Manometric Reading	Spinal Fluid Total Protein, Mg /100 Cc.
1 L K S	Not done	Not done	11 M R L	Normal	24
2 C L M	Normal	57	12 M E Y	Normal	45
3 W H W	No report	No report	13 E F E	Normal	33
4 E P P	Normal	32	14 L S S	Normal	No report
5 L R G	Not done	Not done	15 S H	Not done	Not done
6 G L C	Normal	84	16 G M	Not done	Not done
7 V D C	Normal	43	17 Y E	Partial block	Pandy 2+
8 V L T	Normal	57	18 M G H	Partial block	62
9 H F S	Normal	No report	19 L M B	Normal	29
10 T G H	Normal	33	20 H T	Partial block	11

normal and the increase in the total protein levels of the spinal fluid will be so small that no conclusions can be drawn. In the few cases in which the subarachnoid block is complete, the manometric readings and greatly increased total protein levels in the spinal fluid still will not give more than a hint of the level of the lesion.

OPERATION

The operative procedure for cervical disks is somewhat similar to that for the lumbar region, but it is more of a risk. The patient is placed in a sitting position, in the Craig headrest with the head flexed forward. This position not only decreases bleeding but aids greatly in the exposure of the lesion. Because of flexion of the neck, solution of tribromoethanol and ether administered intratracheally is preferred as the anesthetic in order to prevent obstruction of the airways. Local anesthesia may be

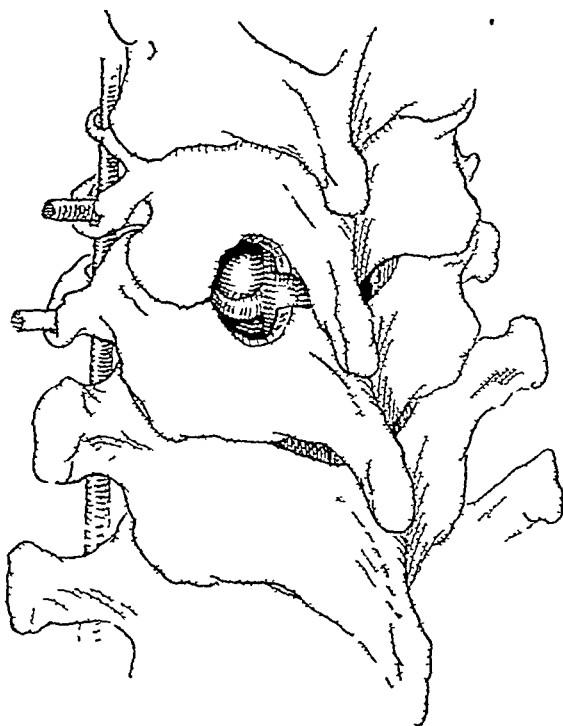


Fig. 4—Exposure of ruptured cervical disk.

used and is helpful in locating the correct interspace by application of pressure over the ligamentum flavum as suggested by Semmes, this, however, usually is an extremely uncomfortable procedure for the patient. A midline incision is made from the spinous process of the fourth cervical to the first dorsal spinous process, and the posterior muscles in the neck are separated in the midline by close to blunt dissection to decrease bleeding. The muscles are then stripped subperiosteally from the spinous processes and the laminae of the fifth, sixth and seventh cervical vertebrae on the side of the lesion. The roentgenograms should

be studied carefully in regard to the spinous processes, since in the cervical region there is not a definite landmark comparable to the sacrum which is so extremely helpful in orientation in the lumbar region. Usually there is a pronounced bifurcation of the tip of the fifth cervical spine and sometimes also of the sixth but that of the latter is always much shallower. The seventh cervical spine, the longest and most prominent ends in a smooth rounded nodule.

After exposure of the laminae the attachment of the ligamentum flavum is separated from the anterior surface of the lamina above. The caudal one third is then removed with rongeurs from this lamina and the removal carried well laterally (fig 4). In order to accomplish the lateral removal it may be necessary to use a small dental chisel. The ligamentum flavum which is much thinner than that in the lumbar region is removed by sharp dissection. In most cases this will give an adequate exposure for exploring the interspace but frequently it is necessary to remove a small portion of the upper lateral part of the corresponding lower laminae. If a disk is present the nerve root is flattened, displaced posteriorly and exceedingly tense. Usually the lower portion of the root is displaced farther posteriorly by the protruding mass and therefore it is easier to retract the root slightly upward to remove the herniated portion of the disk with forceps. Only the herniated portion is removed and there may or may not be more than one fragment. No attempt should be made to curet the space between the bodies of the vertebrae. During the removal every effort should be made to avoid the large extradural veins and if bleeding is encountered careful hemostasis should be obtained.

SUMMARY

The pathologic anatomy, pathogenesis and the clinical picture as well as the diagnosis and differential diagnosis of a ruptured cervical disk have been discussed briefly. The type of operation for the removal has been outlined.

Twenty cases of ruptured intervertebral cervical disk have been reported in order to emphasize the symptoms and signs from which a diagnosis may be made clinically.⁸ It is noteworthy that 16 of the 20 cases were those of pure root compression and only 4 were those of cord compression. The possibility that the high percentage of root compressions in our series as compared with those in the older reports of ruptured cervical disk may be due to earlier recognition is set forth and the idea entertained that the pathogenesis should be divided at times into three stages: (1) the root compression, (2) the unilateral cord compression with masked root compression and (3) the bilateral cord compression with masked unilateral or bilateral root compression.

8 A complete follow up is not given as the interval of time after operation has not been sufficient in all the cases listed.

A history of an initial and of repeated trauma was obtained in the majority of the cases. Twelve of the 20 patients were men in the age group of 36 to 56 years, and 8 patients were women in the age group of 32 to 59 years.

Lumbar puncture was done in 16 instances, manometric readings were made in 15 and total protein contents of the spinal fluid were estimated in 15 of the 20 cases. Myelography was done in all cases of cord compression and in 9 cases of pure root compression.

CONCLUSION

The diagnosis of a ruptured cervical disk is primarily clinical, and the history and subjective complaints are of maximal importance for arriving at an early recognition of the condition. Reproduction of the pain and paresthesias will be possible almost without exception as long as the syndrome is in the stage of root compression. After cord compression has occurred myelography is the method of choice for arriving at a diagnosis of the level and, in many instances, for justifying an etiologic diagnosis.

In the present cases of lateral protrusions the operative results, without exception, have been good. In the cases of cord compression the recovery has not been as spectacular or always complete.

ADDENDUM

Since the submission of this paper 18 more patients with a ruptured cervical disk have been operated on, one of whom had a combined root and cord compression, the remainder had uncomplicated root compressions.

Dr. Barnes Woodhall, Associate Professor of Surgery in Charge of Neurosurgery, Duke University School of Medicine, assisted us by reading and correcting this article.

STREPTOMYCIN AND PARACHLOROPHENOL IN SURGICAL INFECTIONS

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THE HISTORY of streptomycin is a story of a planned search for an antibiotic agent capable of bactericidal and bacteriostatic action on gram-negative bacteria, a substance capable of action in the animal body as well as the test tube, with low toxicity and high resistance to inactivation by circulating body fluids and exudates from wounds. In view of the remarkable success obtained, it is natural that streptomycin be given exhaustive and repeated laboratory and clinical trial against the mixed infections seen so frequently in the surgical field.

This study was designed to coordinate the bacteriologic findings in the laboratory with clinical evaluation and tests on a group of burns, ulcers and infected wounds caused by a mixture of bacteria, predominantly gram-negative. Of great importance is the fact that almost all the cultures of material from wounds were made on material from infections clinically resistant to penicillin and sulfonamide drug therapy. It is believed that the percentage of gram-positive bacteria was thereby lessened and that more resistant species were present.

The effect of streptomycin alone and its effect when mixed with agents used commonly for local treatment in surgical infections have been investigated. Sulfanilamide, penicillin, urea tyrothricin, chlorazodin and parachlorophenol have been given greater or lesser trial when added to streptomycin solutions or ointment bases.

These substances were added for the following theoretic considerations: (a) that one or more of them might give evidence of stability in mixed with streptomycin, (b) that if streptomycin-inactivating substances were found in exudates from wounds there would be less possibility for clinical failure if a second, and unrelated, agent were ready as a block, and (c) that the addition of an extra bacteriostatic or bactericidal substance would lessen the prospect of the development of a streptomycin-resistant or drug-resistant bacterium in wounds under

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The opinions and views set forth in this article are those of the writer and are not to be considered as reflecting the policies of the Navy.

treatment. In the course of investigation parachlorophenol seemed best and was used with streptomycin to the exclusion of the other agent.

Melenev¹ has shown that parachlorophenol in a dosage of 0.25 or 1 per cent may be applied locally in certain infections whose bacteria produce penicillinase and will offset this action, thereby allowing penicillin to act against the associated more important organisms. Especial reference to this aspect seemed indicated with streptomycin and parachlorophenol.

EXPERIMENTAL DATA

A Classification of Bacteria Found in Wounds and Their Resistance to Certain Bacteriostatic Agents—Preliminary experiments were conducted to classify bacteria found in local wounds and to establish the concentrations of separate bacteriostatic agents which were necessary to inhibit the growth of these bacteria in wounds. This was necessary as a basis on which to make up the different admixtures of streptomycin for enhancement and deterioration tests and for clinical usage. In addition it seemed conceivable that one might find a somewhat different group of bacteria in wounds in the tropics and among the Guamanian native population.

Material from thirty different infected wounds, burns, ulcers and impetiginous infections was cultured. From these, fifty-three different species of bacteria were isolated for study. In the main they were gram-negative bacteria from wounds in patients who had received penicillin parenterally and/or sulfadiazine by mouth but gram-positive diphtheroids and cocci were also present.

Bergey's "Manual of Determinative Bacteriology" (fifth edition 1939) was used as much as possible in naming unknown strains. It was soon obvious that some species could be typed only as to genus despite exhaustive metabolic and fermentation tests. The term "Bacterium" is used to cover species of non-spore-forming, rod-shaped bacteria whose position in the system of classification is not definitely established (Breed and Conn²).

The exact identification of bacteria present in wounds is often not among the simplest problems of bacteriology, for the multitude of organisms existing in some infected burns, for example, is startling. In addition an unknown organism may easily be a species or a variant which has never been named or perhaps never adequately described. The authors of Bergey's manual are frank to admit that perhaps the

1 Melenev, F. L. (a) Treatment of Mixed Infections with Penicillin. *J. A. M. A.* **130** 121-124 (Jan. 19) 1946. (b) Penicillin in the Treatment of Established Surgical Infections, *Ann. Surg.* **124** 962-980 (Nov.) 1946.

2 Breed, R. S. and Conn, H. J. The Status of Generic Terms "Bacterium". *Ehrenberg* 1828. *J. Bact.* **31** 517-518 (May) 1936.

TABLE 1—List of Bacteria, Classified According to Bergey's "Manual of Determinative Bacteriology" (5th Edition), Isolated from Infected Wounds of Naval Personnel and Guamanian Native Patients Before Treatment with Streptomycin Injections (Most Patients Had Received Large Amounts of Penicillin and Sulfonamide Drugs)

Tubes were read at forty eight to seventy two hours for the sensitivity tests. Broth was 1 per cent of Difco yeast extract in Bacto nutrient broth tubed in 2 cc amounts to which 1 cc of the agent to be tested was added in sterile isotonic solution of sodium chloride. This medium which was dextrose free and low in phosphate was considered satisfactory. Waksman and associates⁴ have shown that the presence of dextrose phosphate salt and an acid medium tend to reduce streptomycin's activity. The parachlorophenol solution more concentrated than 1:50 was buffered to pH 6.5 with sodium hydroxide before it was added to the culture medium. The inoculum was usually 0.01 cc of a twenty four hour broth growth of the bacterium to be tested. Tryptose-phosphate broth was usually used for streptomycin titrations with the facultative anaerobes. Incubation was then done in an anaerobic jar.

Genus and Species	Total in Genus	Range of and Average Concentration of Agents Needed to Inhibit Growth *			
		Streptomycin Micrograms per Cc of Broth	Parachloro- phenol Dilution	Chloro- zodin Dilution	Penicillin Oxford Units per Cc. of Broth
Genus <i>Pseudomonas</i>	8	Range	Range	Range	Average
Species <i>aeruginosa</i> (2)		7 to 200	1:750 to	1:400 to	2,500 plus
Species unidentified (2)		Average	1:8,000	1:50	
Species <i>incognita</i> (1)		100 plus	Average	Average	
Species <i>jaegeri</i> (1)			1:1,500	1:500	
Species <i>pirantoni</i> (1)					
Genus <i>Micrococcus</i>	5	Range	Range	Average	Average
Species <i>ureae</i> (3)		10 to 50	1:800 to	1:50 plus	2,000 plus
(gram negative)		Average	1:4,000		
Species <i>aurantiacus</i> (2)		100	Average		
			1:1,000		
Genus <i>Staphylococcus</i>	6	Range	Range	Average	Range
Species <i>aureus</i> ()		0.5 to 75	1:800 to	1:500	1:500
(coagulase negative) (2)		Average	1:3,000		Average
(coagulase positive) (1)		20	Average		15
Species <i>citreus</i> (2)			1:1,200		
Species <i>aerogenes</i> (1)					
Genus <i>Diplococcus</i>	3	Range	Range	Average	Range
Species <i>mucosus</i> (1)		0.5 to 10	1:3,000 to	1:1,000	50 plus
Species unidentified (2)		Average	1:5,000		
(facultative anaerobes)		0.6			
Genus <i>Streptococcus</i>	2	Range	Not tested	Not tested	Not tested
Species <i>faecalis</i> (1)		1 to 15			
Species <i>pyogenes</i> (1)		Average 7.5			
(facultative anaerobe)					
Genus <i>Escherichia</i>	8	Range	Range	Average	Average
Species <i>coli</i> (5)		0.3 to 50	1:800 to	1:400	2,500 to
Species <i>freundii</i> (3)		Average	1:3,000		4,000
		15	Average		
			1:2,000		
Genus <i>Aerobacter</i>	2	Average	Average	Not tested	Average
Species <i>aerogenes</i> (3)		40	1:2,000		2,000
Genus <i>Proteus</i>	5	Range	Range	Average	Average
Species <i>vulgaris</i> (3)		3 to 15	1:600 to	1:400	2,500
Species <i>mirabilis</i> (1)		Average	1:3,500		
Species <i>Morganii</i> (2)		7	Average		
Species unidentified (3)			1:800		
Genus <i>Bacterium</i>	4	Range	Range	Not tested	Not tested
Species unidentified (4)		1 to 500	1:800 to		
		Average	1:4,000		
		50	Average		
			1:1,500		
Genus <i>Achromobacter</i>	1	Not tested	Not tested	Not tested	Not tested
Species <i>coccoides</i> (1)					
Genus <i>Corynebacterium</i>	3	Range	Range	Not tested	Average
Species <i>xerosis</i> (1)		1 to 250	1:1,000 to		1,000
Species <i>ulcerogenes</i> (1)		Average	1:2,000		
Species unidentified (1)		35	Average		
			1:1,250		
Genus <i>Chromobacterium</i>	2	Average	Average	Average	500
Species <i>lanthimum</i> (1)		50	1:1,000	1:400	
Species unidentified (1)					

* There was a total of fifty three strains

description and name of a bacterium may have been overlooked, for the number of species described in the literature is so great that no person can know all the species. Thus no apology is offered for the number of species unidentified within the genera in table 1.

It is of real worth to have an enriched medium which will support the growth of fastidious bacteria, aerobically and anaerobically, and yet suppress the "spreader" colonies such as *Proteus*, which overgrow and suppress the coexisting species. Of value here has been a blood agar plate to which 5 per cent alcohol has been added. First described by Floyd,³ this medium, if used within five days of being made up, will allow colonies to be picked and identified forty-eight hours or longer after inoculation, even in the presence of predominant *Proteus* growth.

Material from wounds was cultured by the removal of bits of the edge of the skin if there was any suggestion of erythema of the tissues at this site or evidence of advancing infection. This tissue was triturated in sterile isotonic solution of sodium chloride, and aerobic and anaerobic thioglycollate cultures were made from the suspension. It will be noted in table 1 that two strains of *Diplococcus* and one strain of *Streptococcus* were facultative anaerobes, but most of the bacteria grew well aerobically. These results with anaerobic cultures, combined with the clinical appearance of most of the wounds, would seem to indicate that the tabulated strains did indeed represent the virulent organisms and not just surface contaminants which were responsible for the continued presence of infection in the tissue.

Table 1 shows the fifty-eight species of bacteria in wounds isolated, studied and typed. Also indicated are the average sensitivity and the range of sensitivity within each bacterial genus to streptomycin, para-chlorophenol, chlorazodin and penicillin. It will be noted that the four genera which had species most resistant to streptomycin were *Pseudomonas*, *Micrococcus*, *Corynebacterium* and *Bacterium*. Rare strains showed growth after forty-eight hours in as much as 250 to 500 micrograms of streptomycin per cubic centimeter of medium with a moderate inoculum. However, in view of the slight but definite effect on cellular growth of concentrations over 200 micrograms (Howes⁴ and Heilman⁵), it was decided not to go higher than 500 micrograms per cubic centimeter for clinical use. Dilution by exudates from wounds would, of course, alter this concentration.

3 Floyd, T. M., and Dack, G. M. Isolation of *Bacterium Necrophorum* in Presence of *Proteus*, *J. Infect. Dis.* **64**: 269-272 (May-June) 1939.

4 Howes, E. L., cited by Waksman, S. A., and Schatz, A. Streptomycin Origin, Nature and Properties, *J. Am. Pharm. A. (Scient. Ed.)* **34**: 273-291 (Nov) 1945.

5 Heilman, D. H. Cytotoxicity of Streptomycin and Streptothricin. *Proc. Soc. Exper. Biol. & Med.* **60**: 365-367 (Dec) 1945.

Parachlorophenol was effective against all these organisms in a 1 500 (0·2 per cent) solution, and usually a 1 1,000 dilution showed complete inhibition of bacterial growth *in vitro*. This substance was considered more effective in a 1 500 dilution against the bacteria from wounds isolated and tested *in vitro* than chlorazodin, penicillin and sulfanilamide in concentrations usually used locally.

Tests were then made to determine the stability of mixtures of streptomycin and parachlorophenol and of streptomycin mixed with other bacteriostatic substances. A strain of *Escherichia freundii* and of *Proteus morgani* being used as test organisms, it was found that little or no real deterioration of bactericidal titer occurred in streptomycin admixed with parachlorophenol after ten days at room temperature. There was a slight loss of titer after ten days at 37 C. After being autoclaved fifteen minutes at 20 pounds (9 Kg.) of pressure, this streptomycin admixture showed a loss of titer only from 0·5 to 40 micrograms per cubic centimeter.

For practical purposes streptomycin can then be mixed with any of the aforementioned bacteriostatic agents and if stored at 5 C. and used within one week will not suffer material loss. In especial reference to parachlorophenol it would seem that it is compatible with streptomycin and superior to these other agents as determined by *in vitro* tests.

In order to test this hypothesis further, material from eighteen wounds was cultured, all of which had two or more bacterial species in symbiosis. The predominant organism as determined by blood agar streaking was *Staphylococcus aureus* in 4, *Proteus* in 4, *Escherichia coli* in 3, *Chromobacterium* in 2, *Micrococcus* in 2, *Pseudomonas* in 2 and a diphtheroid in 1. In every case a mixture of streptomycin (500 micrograms per cubic centimeter) in parachlorophenol (1 500) and a 1 3 and 1 5 dilution of this in isotonic solution of sodium chloride were sufficient to suppress growth in nutrient broth for seventy-two hours. A 0·01 cc. inoculum of a twenty-four hour broth culture was used.

Meleney and associates^{1a} reported Howes's statement that parachlorophenol in the concentration 1 500 (0·2 per cent) has no appreciable effect on the healing of experimental wounds in rabbits. The absence of cytotoxicity of this concentration, along with its powerful bacteriostatic effect on gram-negative bacteria (table 1) and its stability when mixed with streptomycin (mentioned previously), led me to confine my clinical trials to streptomycin 500 micrograms per cubic centimeter in parachlorophenol 0·2 per cent. However since the halogenated phenols are readily absorbed, the possibility of remote systemic toxic effect from prolonged local application must be borne in mind. In addition it would seem unwise to inject parachlorophenol into tissues surrounding a chronic resistant ulcer—a procedure which with penicillin and streptomycin is sometimes of real value and without harm. Parachlorophenol however,

is useful as an agent for topical application and, as Meleney¹ showed, is a good adjuvant with penicillin in some instances

B The Local Use of Combined Streptomycin and Parachlorophenol in Infected Wounds, Burns, Ulcers and Cutaneous Lesions—(a) Combination of Streptomycin and Parachlorophenol in Liquid Phase Streptomycin (500 micrograms per cubic centimeter) is readily soluble in water. Parachlorophenol is a somewhat oily liquid with a specific gravity of 1.31. A 1:500 dilution (by weight) is soluble and has a pleasant phenolic odor, which is of value as a deodorant in some wounds. Parachlorophenol is moderately acid, and because the optimal activity of streptomycin is at p_H 9 (Waksman and colleagues⁶) it was thought best to adjust the p_H of the streptomycin-parachlorophenol mixture at 7.5, easily handled by the tissues.

(b) Use of Several Different Ointment Bases. Ointment base I was composed of cetyl alcohol 10.0 per cent and water 79.0 per cent. Ointment base II contained sodium benzoate 0.2 per cent, stearic acid 10.0 per cent, glycerol monostearate 5.0 per cent, glycerol laurate 5.0 per cent, glycerin 10.0 per cent and distilled water 69.8 per cent.

Ointment base III contained carbowax 4,000 (45 per cent) and propylene glycol (55 per cent) by weight.

In the tropics it was found desirable to combine these bases with an equal part of cold cream base whenever they were incorporated with sterile gauze for use in burns. This procedure seemed to allow the ointment to stick to the gauze longer and therefore to remain longer in contact with the burned area. At the same time it should retain enough of the desirable water-soluble property for the release of streptomycin and parachlorophenol to the tissues. These agents were homogenized with the base in question so that streptomycin (500 micrograms) and parachlorophenol (0.2 per cent) were in each gram of ointment.

Insufficient clinical trial was performed, and therefore no significant comparison could be made between these bases. All of them seemed to be satisfactory and would theoretically be superior to hydrous wool fat, petrolatum or greases for incorporation of antibiotic agents, so far as they release the bacteriostatic agent to the tissues more readily.

All ointments containing streptomycin-parachlorophenol were tested by rubbing them well into the intact skin of the anterior parts of the forearms of 15 normal human volunteers. In no case was any erythema or reaction noted.

⁶ Waksman, S. A., Bugie, E., and Schatz, A. Isolation of Antibiotic Substances from Soil Micro-Organisms with Special Reference to Streptomycin and Streptomycin (Mayo Foundation Lecture), Proc. Staff Meet. Mayo Clin. 19: 537-548 (Nov. 15) 1944.

The addition of cold cream to the ointment seemed to diminish the sensation of slight burning of which some burned patients complained when the ointment gauze was first applied. In 1 patient with a chronic "tropical" ulcer of the leg the ointment briefly accentuated an already present erythema at the edge of the lesion. Otherwise there was no suggestion of toxicity.

C Treatment in Clinical Cases—Table 2 summarizes the significant data obtained in treatment of 10 patients with infected burns, ulcers and wounds. During treatment frequent cultures were made and they were carefully observed from the clinical standpoint.

Of particular interest, but not necessarily invalidating the use of streptomycin-parachlorophenol, was the development of streptomycin-resistant bacteria in some treated wounds. In 2 of the 10 cases such a situation developed, and in both of these it was a bacterium of the *Pseudomonas* genus which became resistant. In case 3 the original species of *Pseudomonas* isolated before treatment was inhibited by 100 micrograms of streptomycin per cubic centimeter of broth and by 1 2,500 parachlorophenol. Under treatment it became resistant to as high as 18,000 micrograms per cubic centimeter but was not able to grow in parachlorophenol 1 500 or 1 2,500. This illustrates the development of resistance under treatment to one but not to another agent which has been given simultaneously. Thus, in this instance the theoretic advantage of one agent acting as a block to growth, in case of resistance acquired against another agent, was shown to have practical importance. It will be remembered that it was in part for this theoretic reason that streptomycin was admixed with parachlorophenol originally in the in vitro tests.

In case 9 the bacterium became insensitive to 10,000 micrograms of streptomycin per cubic centimeter but was susceptible to 1 500 parachlorophenol.

In a few instances there remained the possibility that prolonged use of the ointment gauze had retarded epithelization. However, having investigated such a small group of patients, one is not justified in commenting, other than to state it as a potential danger.

In general the combined use of streptomycin and parachlorophenol was found to be of value in some cases for the local treatment of the mixed infections seen in surgery. As no attempt was made to compare it to tyrothricin (Kozoll⁷) or to streptomycin and Sulfamylon (para-[aminomethyl]-benzene sulfonamide) (Howes⁸) no statements relative

7 Kozoll, D. D., Meyer, K. A., Hoffman, W. S., and Levine, S. The Use of Tyrothricin in Surgical Infections, *Surg., Gynec. & Obst.* **83** 323-342 (Sept.) 1946.

8 Howes, E. L. Prevention of Wound Infection by the Injection of Nontoxic Antibacterial Substances, *Ann. Surg.* **124** 268-276 (Aug.) 1946.

TABLE 2—Clinical Cases in Which Treatment Was Done with Streptomycin-Paraldehydeol

Patient	Age Yr	Sex	Diagnosis	Streptomycin and Parchlorophenol Used as	Duration of Treatment	Earlier Treatment with Penicillin and Sulfonamide Drugs	Change in Bacterial Flora with Treatment	Comment
1 I D	33	Male	Appendiceal abscess and an abscess in abdominal wall postoperatively treated for the latter	Solution for irrigation and as ointment gauze for packing	2 wk	Yes, both in large amounts for 4 wk (parenteral and oral, not local)	At beginning pure growth of a facultative anaerobic diplococcus after treatment occasional Proteus	Rapid and gratifying improvement which kept the abscess cavity clean until early and complete healing resulted
2 O P	19	Male	Second degree burns of right leg 8 by 10 cm	Ointment gauze	6 days	Penicillin only 100 000 units parenterally and penicillin compresses for 3 days	At beginning (a) Esch coli, small numbers and (b) Chromobacterium after treatment cultures sterile or occasional Micrococcus	Appearance of wound improved (a) less exudate (b) felt better to patient and (c) epithelialization more rapid
3 H M	13	Male	Extensive 2d and 3d degree burns of legs from kerosene	Wet compresses and as ointment gauze	70 days	Yes, both in large amounts for 3 and 6 wk (parenteral and oral not local)	At beginning rampant, foul smelling mixed infection with (a) P. vulgaris (b) Esch coli, (c) Chromobacterium and (d) Micrococcus after streptomycin treatment resistant strain of (a) Pseudomonas and (b) occasional Proteus	Great clinical improvement in first week of treatment (1) temperature fell and (2) burns improved in appearance and lost foul odor and discharge last week of treatment showed little advantage over petrolatum gauze greenish pus
4 I R	3	Male	Extensive 2d and 3d degree burns of arms and face	Ointment gauze	3 wk	Yes both for 2 wk prior to streptomycin	At beginning (a) P. moraxii, (b) diphtheroid and (c) Bacterium genus after streptomycin treatment from negative micrococci	The effect was not impressive healing was slow petrolatum gauze after 3 wk of treatment
5 I M	43	Male	"Tropican" ulcer on leg, at least partly explained by inadequate venous drainage	Ointment gauze and wet compresses local injections of streptomycin alone	7 1/2 wk	Large amounts of penicillin, both considered sensative to sulfadiazine	At beginning (1) Esch freundii (2) O. versae and (3) Staph aureus after streptomycin treatment occasionally an unidentified diphtheroid	The infectious element of this ulcer was easily controlled by treatment healing was slow but helped by Ace bandage and rest
6 I S	23	Male	Chronic leg ulcer of 6 mo duration had been excessively treated with mercurials 8 cm in diameter negative kaolin reaction	Ointment gauze local injections of streptomycin alone	3 wk	Had had large amount of both drugs recent penicillin compresses	At beginning (1) Streptococcus, (2) P. moraxii after streptomycin treatment repeatedly sterile cultures	The infectious element was easily controlled this ulcer had a fibrous base and underlying perostitis definite slow improvement
7 I B	21	Male	Chronic leg ulcer of 6 mo duration 3 cm in diameter	Ointment	2 wk	Yes had had	At beginning (1) Ps aeruginosa after treatment occasional Micrococcus	Improvement was striking
8 I D	1	Male	Excised phloidal sinus with primary culture reported inferior aspect of wound after infection occurred	Ointment gauze after a few days irrigation	3 wk	No	At beginning (1) Esch coli (2) Staph aureus (3) P. aeruginosa after treatment cultures were sterile occasionally A. aerogenes	Healing was rapid discharge from the wound eliminated from large amounts to scant
9 I R	9	Male	Surface infection of rubber stamp bit	Wet compresses and ointment gauze	2 wk	Yes both given in large amounts	At beginning (1) O. necrops, (2) Staph aureus after streptomycin treatment sterile cultures	Difficult to assess the value here further surgical treatment was necessary to open subcutaneous abscesses present in the rubber stamp surface

to these agents can be made. There would seem to be a few practical points favoring Sulfamylon over parachlorophenol so far as its range of activity against most strains of streptococci is excellent and its toxicity is less than parachlorophenol.

It may well be that the main indication for combined use of streptomycin-parachlorophenol would be for topical application on a badly infected burn, abscess or wound resistant to penicillin and sulfonamide drugs, and then its use would be for a matter of days only, because of the danger of acquired resistance to streptomycin. Of equal importance may be its short term use as a local agent with penicillin given intramuscularly in the presence of overwhelming mixed infections associated with widespread burns or large, deep abscesses.

However, in recent investigations, Herrell and Nichols,⁹ Pulaski¹⁰ and others have indicated that in the presence of inadequate dosage of streptomycin or even in the presence of large amounts of it some pathogenic bacteria may develop resistance to this antibiotic in a short time. In some respects, then, these findings dampen the enthusiasm for the prolonged or inadequate use of streptomycin on wounds. There is no evidence from my experimental work, however, that streptomycin resistance develops against an organism ordinarily responsible for bacteremia or serious systemic infection, for *Pseudomonas* is not a usual invader of the blood stream. In addition I believe that its bactericidal effect on such a wide variety of gram-negative organisms, its low toxicity and its ability, if needed in an invasive infection, to be injected around and into a wound, which is probably unwise with parachlorophenol, indicate the use of streptomycin in certain infections as a local agent. Used with parachlorophenol there may be less chance for resistant strains to develop against streptomycin. Further investigations are warranted, and no claim is made that this suggestion is always true or conclusive.

The decision to use streptomycin, then, must weigh the dangers of its inducing acquired bacterial resistance against the advantages it offers in certain cases of gram-negative or mixed bacterial infections seen in surgery. One of its main advantages is its usefulness for local injection into and around the edge of the wound in chronic or advancing lesions if penicillin seems ineffective in such an infection.

The criticism which may be levied against streptomycin on the basis of the "acquired resistance" property applies also to other agents used locally on wounds, although probably to a lesser extent. Sulfonamide drugs, some antibiotics and inorganic and organic agents all induce

9 Herrell W. E., and Nichols D. R. Clinical Use of Streptomycin. Proc. Staff Meet., Mayo Clin 20: 449-462 (Nov. 28) 1945.

10 Pulaski, E. I. Streptomycin in Surgical Infections. Ann Surg 124: 392-401 (Aug.) 1946.

bacterial resistance, in greater or lesser extent, following prolonged use Gram-negative bacteria as a group are more hardy, resistant bacteria than gram-positive bacteria (Dubos¹¹), and it is to be expected that the gram-negative group would overcome more quickly any obstacle whether antibiotic or otherwise, which inhibits their metabolism in general or their enzymatic, intermediate chemical processes. Streptomycin has proved effective against many difficult therapeutic problems in gram-negative bacterial infections, and while it is by no means a perfect agent, it has its useful place in the surgical armamentarium until something superior to it is discovered.

COMMENT

Again and again one is impressed in such a study with observations which illustrate the multiplicity of factors, besides simple bacterial infection, which may prevent or retard healing in infected lesions. Poor blood supply or circulatory stasis, minute or large foreign bodies, inadequate nutritional status or blood dyscrasias, hypersensitivity to drugs or food, inadequate drainage, overactive fibrosis or structural changes in the wound itself are some among many of these important factors. It is to be emphasized that no treatment, local or systemic, with antibiotics or antibacterial agents can be successful unless one is constantly on the alert to counteract or prevent these aforementioned conditions from obtaining the upper hand. In many cases, it is of far more importance to alleviate such an undesirable condition than it is to change the species of bacteria in a wound, or even to keep it reasonably sterile. Antibiotics are no substitute for good surgical principles. In view of much recent work with these agents, it seems wise to emphasize this repeatedly.

The local use of agents designed for their effect on bacteria present in wounds meets with other problems, among which are the dilution of the agent by exudate from the wound and the mechanical failure to get the agent to the bacteria which lie deeper in the tissues than on the surface. Intelligent treatment will sometimes dictate such procedures as trimming off exuberant granulation tissues, compressing or debriding eschars and crusts and in some cases revising the wound surgically. As an example of the latter, fibrotic chronic ulcers of the lower leg may respond to excision, local compressing with streptomycin and grafting. In some resistant infections, as indicated before, local injection of streptomycin or penicillin into the periphery of the infection may succeed in benefiting the lesion by establishing a high concentration of antibiotic in the area in which it will do the most good.

11 Dubos, R. J. *The Bacterial Cell in Its Relation to Problems of Virulence, Immunity and Chemotherapy*, Harvard Monograph in Medicine and Public Health. Cambridge, Mass., Harvard University Press 1945.

Dr Meleney, of New York city, has been a leader in the investigation of surgical infections, and the impact of his thinking is acknowledged. One is too often a spectator at the "dumping" of some agent on or in a wound or sinus whereby the corpsman or doctor is obviously unaware of the agent's toxicity or its inability to act on or reach the bacteria responsible for the infection. It is hoped that the somewhat optimistic findings of this article will not increase the incidence of such irrational treatment.

So far as there is yet much to learn about antibiotics in relation to the mixed and symbiotic bacterial infections seen so commonly in surgery and so far as there is no simple correlation between *in vitro* and *in vivo* results with streptomycin, it would seem advisable to deter optimism until further clinical studies with this antibiotic are made.

SUMMARY

1 Bacteria found in burns, ulcers and wounds, generally resistant to sulfonamide drugs and penicillin, were classified and tested for sensitivity to streptomycin, parachlorophenol chlorazodin and penicillin.

2 A mixture of streptomycin 500 micrograms per cubic centimeter and parachlorophenol 0.2 per cent was found adequate for the suppression of growth of all bacteria *in vitro* before treatment and preferable to other agents tested. The stability of this mixture is adequate for practical purposes.

3 In 10 cases infected burns, ulcers and wounds found in Guamanian natives and United States Naval personnel were treated locally with the streptomycin-parachlorophenol mixture as a solution or incorporated in various ointment bases, with generally good results.

4 Streptomycin-resistant strains of the genus *Pseudomonas* developed in some instances *in vivo* after treatment. The suggestion is made that perhaps local treatment with streptomycin should not be for long periods. The danger of development of resistant strains, although apparently real and possibly common with prolonged use, should not contraindicate use of streptomycin in selected cases.

5 The injection of streptomycin, 200 micrograms per cubic centimeter, into the periphery of some wounds seemed of benefit.

6 It should be emphasized that these agents are only adjuvants and cannot replace good surgical principles.

Lieutenant T. M. Floyd, H(S), USNR., Chief Pharmacist's Mate; O. L. Selman, K. P. Egner and R. H. St. John, and Pharmacist's Mate, Third Class C. R. Poore and Theodore Stone gave assistance in this work. Chemical preparation of parachlorophenol was accomplished by Ensign L. E. Miller, H(S), USNR.

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PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

VII TUBERCULOSIS OF BONES AND JOINTS

Prepared by

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(Continued from Page 219)

LEWIS¹⁵⁶ expresses the opinion that Phemister's criteria, used in distinguishing tuberculous and nontuberculous (pyogenic or suppurative) arthritis, are of such importance as to warrant restatement.

In pyogenic (nontuberculous) arthritis, Phemister states that the articular cartilage is destroyed first at the points of contact and pressure and necrotic material is rapidly removed with the assistance of proteolytic ferments. However, the articular cartilage is not destroyed first in tuberculous arthritis but is protected at points of contact and pressure, the earliest destruction being peripheral, where tuberculous granulations can grow onto and remove the cartilage. The proteolytic ferments are not present as in pyogenic arthritis, so that masses of dead cartilage may persist for months or years. Also, the first evidence of destruction of bone is usually peripheral, where there has been absorption by the tuberculous granulations.

Thus, in terms of roentgenology, the joint space is narrowed early in pyogenic arthritis, while the joint space is preserved in tuberculous arthritis for months or years.

Added distinguishing characteristics are the following ones: 1 Severe osteoporosis is present about the joint in acute suppurative arthritis as result of acute congestion. This is not seen in tuberculous arthritis. 2 Repair and ankylosis are more the rule in pyogenic than in tuberculous arthritis. 3 Adjacent muscular atrophy is seen in tuberculous arthritis but not in pyogenic joint disease.

[Ed. NOTE (A. D. S.)—Thinning of the joint or cartilage space has been seen regularly in roentgenograms at an early stage of tuberculosis of the joint in cases in which the diagnosis subsequently was proved at operation. We have come to regard it as one of the early evidence of tuberculosis.]

¹⁵⁶ Lewis, R. W. Differential Diagnosis of Tuberculosis in Joints of Extremities, *Am. J. Roentgenol.* 54: 329-337 (Oct.) 1945.

Wood and Wilkinson¹⁵⁷ emphasize the importance of lateral roentgenography in the early diagnosis of tuberculosis of the hip. Roentgenography provides a means of tracing the different phases of the disease, that is, the destructive and the reparative stages. The roentgenologic changes appear late in the disease of the hip as contrasted to pulmonary tuberculosis, and this is a handicap in the diagnosis.

As in other inflammatory disease of bone, the earliest change in tuberculosis is rarefaction due to hyperemia. Later, the articular cartilage becomes absorbed, a pannus spreading over it from the periphery. The edge of the cartilage is absorbed first. Subsequently the joint becomes narrower than normal, although initially the joint may be distended by fluid. In another type of disease there is cavitation in the bone close to the articular margins in the early stage, with the joint space being affected later.

The lateral roentgenograms are taken with the patient lying on the affected side. The opposite leg is drawn backward, and the pelvis is rotated so as to form an angle of 65 degrees with the horizontal. The anterior-posterior roentgenograms are taken in the usual manner. The lateral roentgenogram provides a more extensive view of the hip joint and also assists in the localization of tuberculous lesions.

Protar¹⁵⁸ discusses the similarity in the roentgenologic findings between the *caries sicca* type of tuberculosis of the shoulder and epiphysitis of the proximal humeral epiphysis. He states that epiphysitis of the proximal humeral epiphysis is similar to Legg-Calve-Perthe disease of the hip and that the roentgenologic differences are due to the fact that the hip is a weight-bearing joint and thus subjected to forces different from those of the shoulder.

Seligson¹⁵⁹ states that there has been little acceptance in America of the fact that the numerous extrapulmonary inflammatory and degenerative lesions described by Poncet and Leriche belong to the clinical picture of tuberculosis. The wide variety of manifestations, including transitory inflammatory changes in joints and serous cavities which they described, have not been proved tuberculous by routine bacteriologic and pathologic tests but Poncet and his disciples were of the opinion that bacillary toxins rather than the tubercle bacillus cause tuberculous rheumatism.

157 Wood, F. G. and Wilkinson, M. C. X-Ray Examination of Hip-Joint in Tuberculous Disease with Special Reference to Localization of Cavities and Tuberculous Foci, *Brit J Radiol* **18** 332-334 (Oct.) 1945.

158 Willemin, F., and Protar, M. Superior Humeral Epiphysitis. Differential Diagnosis of Volkmann's Dv. *Caries*. Relation to Pathogenesis of Recurrent Luxation of Shoulder. *J de radiol et electrol* **26** 64-66 1944-1945.

159 Seligson, F. Poncet's Disease. Clinical Observations on Inflammatory and Degenerative Joint Reactions in Tuberculosis. *Am Rev Tuberc.* **52** 463-473 (Dec.) 1945.

There are some observations that could give additional weight to Poncet's observations. The work of Loewenstein and others demonstrated tubercle bacilli in the circulation in various conditions (the work has found little support). Rich compared the effects of a striking systemic reaction in tuberculosis (fever, malaise, headache, anorexia, joint pains, backache and prostration) with those of anaphylactic "serum sickness". Klinge was able to prove that the same organism could produce septic and purulent inflammation at one time and allergic reactions distant from the original focus of infection at other times. (Frequently even inoculations of guinea pigs with pleural fluid give negative reactions, but the consequent clinical course shows the development of tuberculosis.) Neumann speaks of "beginning tuberculosis hiding behind rheumatism". Certain other facts could support the conception—the arthropathies following a tuberculin test or following an "ophthalmo-reaction" and the temporal relation between the arthropathies and the pulmonary flare-ups.

The author summarizes 8 cases which could be classified within the group mentioned by Poncet. The importance of serous effusion and rheumatic manifestations in the joints in recognition of cases hitherto not regarded as tuberculosis is emphasized.

Schumann¹⁶⁰ states that clinical, laboratory and roentgenologic examination may fail in diagnosis of tuberculosis of the knee joint. Of 23 cases of chronic hydrops, the conditions in 8 were clinically diagnosed as tuberculosis. In 6 of these the diagnoses were confirmed histologically. In the remaining 15 cases, histologic study revealed tuberculosis present in 5 and absent in 10. All cases of chronic hydrops of knee, even with a history of trauma, should be suspected of tuberculosis.

In the course of observations made on mounted skeletons, Kaplan¹⁶¹ noticed that variation in the mamillary tubercle was found on the twelfth dorsal vertebra when it was compared with other vertebra. The author discusses nomenclature of the transverse and related processes of the eleventh and twelfth thoracic and first lumbar vertebrae.

In examination of spines of human beings it was found that the mamillary process of the twelfth thoracic vertebrae was situated behind the superior articular process and separated from the latter by a deep groove. The relationship between the superior articular process and the mamillary tubercle on the twelfth thoracic vertebrae differed in that the mamillary process is smaller and placed farther back of the superior articular process. Further, there is no deep groove between them. The

160 Schumann, H. D. Exploratory Excision of Capsule in Suspected Tuberculosis. Problem of Trauma in Relation to Tuberculosis. *Chirurg* 16 27 (Jan.) 1944.

161 Kaplan, E. B. The Surgical and Anatomic Significance of the Mamillary Tubercle of the Last Thoracic Vertebra, *Surgery* 17 17-92 (Jan.) 1947.

mamillary tubercle of the first lumbar vertebra is placed lateral to the superior articular process and is entirely unlike that of the eleventh and twelfth thoracic vertebrae. A numerical relationship between the heights of the superior articular process and the mamillary tubercle of the twelfth thoracic vertebra was found to be 25:17.

Spines of a number of other animals were examined, and it was found that the mamillary process was present in all, the relationship in size between the superior articular process and the mamillary tubercle being variable.

In gibbons, however, the mamillary process on the thirteenth thoracic vertebra (the last thoracic vertebra in the gibbon) was found to be similar to that in human beings. It is of interest that gibbons are the only other animals which assume the upright biped position.

The author points out that the semispinalis and the multifidus muscles originate from the mamillary process of the twelfth thoracic vertebra and insert into the spinous processes of the ninth and tenth thoracic vertebrae. The aforementioned muscles together with the rotator muscles probably form a strong group, which plays an important role in this area of functional transition.

The author states that the mamillary tubercle has a surgical significance in that it serves to identify the twelfth thoracic vertebra. Further, since the mamillary process, viewed from behind, covers the articulation between the superior process of the twelfth and the inferior process of the eleventh thoracic vertebrae, it must be removed in order to expose the articulation just mentioned when a Hibbs fusion is done.

An interesting report¹⁶² from the Massachusetts General Hospital presents a 64 year old man who was admitted with a history of sudden onset of pain in the lower part of the thoracic portion of the spine which radiated anteriorly. This subsided over a period of weeks, but he progressively lost strength in his lower extremities and became unable to walk. Roentgenologic examination showed decalcification of the left pedicle of the sixth thoracic vertebra, and two weeks later the pedicle was partially destroyed and there was a defect of the right lateral portion of the body of this vertebra and considerable narrowing of the fifth and sixth dorsal disks. Spinal puncture revealed complete cord block, and the spinal fluid protein content was 114 mg per hundred cubic centimeters. Physical examination showed complete paralysis of the legs, with absence of tendon reflexes and a negative Babinski sign.

The case was discussed by Dr. Arthur L. Watkins and his staff. The diagnosis decided on was compression of the spinal cord by a tumor at the level of the sixth dorsal vertebra. Epidural sarcoma, meningioma.

162 Tuberculosis of Vertebra with Extension to Dura. Massachusetts General Hospital Case 31352. *New England J. Med.* **233**: 281-283 (Aug. 30) 1945.

neurofibroma or metastatic carcinoma were considered most likely diagnoses. About tuberculosis, Dr Watkins stated that "one would not expect to have such a rapid progression of neurologic signs without evidence of more extensive bone destruction, possibly with soft tissue changes, than is apparent in this case."

An exploratory laminectomy was performed, and reddish tissue was found under the sixth dorsal nerve root outside the dura. This tissue extended alongside the nerve root through the foramen. Microscopic examination showed the mass to be tuberculous.

Ahlberg¹⁶³ reports 131 patients with tuberculosis of the wrist who have been under treatment in the Apelvikens Seashore Sanatorium in the period from 1928 to 1940. This number makes 2.2 per cent of the total material on tuberculosis of the bones and joints. Operative treatment was employed in 46, 77 patients were given conservative treatment.

Tuberculosis elsewhere in the body was ascertained in 58 of the patients (44.2 per cent). Forty patients (30.5 per cent) presented tuberculosis of the bones or joints elsewhere, outside the wrist. In 49 patients (37.4 per cent) tuberculosis of the wrist was the only localization of tuberculosis ascertained. Forty-eight (36.6 per cent) of the patients demonstrated tuberculous changes in the lungs during or prior to the development of tuberculosis of the wrist, a number which is probably too low. The right hand was attacked in 65 patients and the left in 64. In 2 patients the lesion was bilateral. In 24 patients the illness lasted less than three months before their admission to the hospital, in 55 the process had lasted over twelve months.

The author emphasizes that in conservative treatment it is highly important that the hand be immobilized in dorsal flexion of 45 degrees from the beginning.

Among the cases of operation in this report, partial resection was done in 2 cases, with a favorable result. In all the other cases of operation total resection was performed. Among the cases of operation healing was obtained primarily in 36 (76.6 per cent). A fistula was formed in 7 cases. On an average, the after-treatment lasted five months.

Tuberculosis of Bones and Joints—Papers continue to appear regarding the therapeutic value of various sulfones and other drugs in experimental tuberculosis¹⁶⁴ and in human tuberculosis of a predominant

163 Ahlberg, A. Tuberculosis of Wrist. Therapy and Results, Acta orthop Scandinav. 14: 153-182, 1943.

164 Tytler, W. H. Sulfone Compounds in Chemotherapy of Tuberculosis. Review of Experimental Results and Pharmacological Data, Tubercle 25: 9 (Nov.-Dec.) 1944, 26: 23 (Jan.-Feb.) 1945. Melville, K. I., and Stehle, R. L. Chemotherapy in Experimental Tuberculosis (Using Aminobenzene, Sulfonamide, and Sulfone Derivatives), Canad. J. Research, Sect. E. 22: 95-121 (Dec.) 1944.

pulmonary type, but the note of optimism for a dramatically successful treatment of human tuberculosis by any of these presently known agents is lacking. They indicate the need of search for drugs of more powerful action and lower toxicity. Streptomycin appears to give promise of considerable usefulness in some types of tuberculosis infection.

The pronounced inhibiting action of diasone (disodium formaldehyde sulfoxylate diaminodiphenylsulfone) on the acute form of primary tuberculosis infection in guinea pigs has been confirmed by Giroux,¹⁶⁵ but he found the action much less striking in the caseous form of pulmonary tuberculosis developing after reinfection.

Petter's¹⁶⁶ general review of his experience with administration of diasone to 170 patients in seventeen months does not indicate that the compound will cure pulmonary tuberculosis or close large cavities. Although the compound exhibited toxic manifestations in the majority of patients, most reactions were only mild. His impression is that changes for the better in certain predominantly exudative lesions have occurred generally faster and in greater degree than would be expected of conventional therapy alone. Fibroid lesions did not respond well. Observed data in the few patients studied with bone, renal, peritoneal, glandular and pleural lesions were almost entirely favorable. Eighty per cent of a small group with genitourinary and osseous tuberculosis (all but 2 patients) showed symptomatic improvement as well as roentgenographic and laboratory evidence of control. Petter feels that diasone judiciously administered is an adjunct to the conventional treatment of tuberculosis and that investigation with the drug should be continued.

Streptomycin and six other antibiotic substances were tested by Schatz and Waksman¹⁶⁷ for their bacteriostatic effect in vitro against *Mycobacterium tuberculosis*. Streptomycin, because of its high activity and lower toxicity, appeared to be the most promising of these agents for practical use against the human tubercle bacillus. It was also highly effective in vitro against *Erysipelothrix* and *Actinomyces*.

McBurney, R., Cason, L., and Searcy, H. B. Effect of Oral Administration of Thiomol on Experimentally Induced Tuberculosis. *J. Lab. & Clin. Med.* **30**: 32-38 (Jan.) 1945. Feldman, W. H., and Hinshaw, H. C. Effects of 4-Amino-4'-Propylaminodiphenyl Sulfone on Experimental Tuberculosis, *Proc. Staff Meet., Mayo Clin.* **20**: 161-166 (May 30) 1945.

165 Giroux, M. Diasone (Diaminodiphenylsulfone Derivative) Therapy of Experimental Tuberculosis of Guinea Pig. Primary Infection and Reinfection. *Laval med.* **9**: 788-803 (Dec.) 1944.

166 Petter, C. K. Experiences with Diasone in Clinical Tuberculosis, *Tuberculosis* **7**: 67-72 (Jan.) 1945.

167 Schatz, A., and Waksman, S. A. Effect of Streptomycin and Other Antibiotic Substances upon *Mycobacterium tuberculosis* and Related Organisms. *Proc. Soc. Exper. Biol. & Med.* **57**: 244-248 (Nov.) 1944.

Five highly virulent human type strains of *Mycobacterium tuberculosis* were found by Youmans¹⁶⁸ to be equally sensitive to streptomycin in vitro. The lowest bacteriostatic concentration was between 0.095 and 0.78 units per cubic centimeter. Within wide limits, the bacteriostatic activity of streptomycin for tubercle bacilli was not significantly affected by the number of organisms or by the presence of human plasma. The bactericidal concentration of streptomycin for 0.1 mg. of virulent human tubercle bacilli was in excess of 50 units per cubic centimeter.

Feldman and Hinshaw¹⁶⁹ and Feldman, Hinshaw and Mann¹⁷⁰ found streptomycin to be well tolerated by guinea pigs and capable, under the several conditions imposed, of exerting in guinea pigs a striking suppressive effect on the pathogenic proclivities of two human strains of *Mycobacterium tuberculosis*. At the end of the most elaborate experiment, in which treatment was started forty-eight days after inoculation and was continued for one hundred and sixty-six days, 52 per cent of the treated animals exhibited no tuberculosis grossly or microscopically and 39 per cent of the treated animals living when the experiment was terminated gave a negative reaction to tuberculin. These results seem to indicate that streptomycin is the most effective in vitro tuberculochemotherapeutic agent at present known.

Youmans and McCarter¹⁷¹ report that streptomycin hydrochloride administered subcutaneously had a distinct suppressive effect on experimental pulmonary tuberculosis in white mice. In the second and most successful experiment, administration of streptomycin in a dosage of 3,000 units daily was started on the day that mice were infected by intravenous inoculation of a human strain of tubercle bacillus. The treatment was continued for twenty-eight days, at which time 87 per cent of the treated animals were living, whereas 2 per cent of the controls were still alive. The lungs of the control animals all exhibited gross lesions estimated to occupy 39 per cent of the pulmonary substance. In the treated mice no gross lesions were visible, but all exhibited microscopic lesions containing tubercle bacilli.

168 Youmans, G. P. Effect of Streptomycin in Vitro on *M. Tuberculosis* var. *Hominis*, Quart. Bull. Northwestern Univ. M. School 19: 207-209, 1945.

169 Feldman, W. H. and Hinshaw, H. C. Effects of Streptomycin on Experimental Tuberculosis in Guinea Pigs. Preliminary Report, Proc. Staff Meet., Mayo Clin. 19: 593-599 (Dec. 27) 1944.

170 Feldman, W. H., Hinshaw, H. C. and Mann, F. C. Streptomycin in Experimental Tuberculosis. Am. Rev. Tuberc. 52: 269-293 (Oct.) 1945.

171 Youmans, G. P., and McCarter, J. C. A Preliminary Note on the Effect of Streptomycin on Experimental Tuberculosis of White Mice. Quart. Bull. Northwestern Univ. M. School 19: 210, 1945. Streptomycin in Experimental Tuberculosis: Its Effect on Tuberculous Infections in Mice Produced by *M. Tuberculosis* var. *Hominis*. Am. Rev. Tuberc. 52: 432-439 (Nov.) 1945.

Hinshaw and Feldman,¹⁷² in a preliminary report based on nine months of collaborative experience with others in the use of streptomycin in 34 tuberculous patients, gained the impression that streptomycin exerted a limited suppressive effect, especially on some of the more unusual types of pulmonary and extrapulmonary tuberculosis. The authors regard 800,000 units per twenty-four hours as the minimum therapeutic dose. Patients were usually given 1,000,000 to 2,000,000 S units per day.

Gerstl, Tennant and Pelzman¹⁷³ report on a study in which mycolic acids isolated by Anderson and associates as long chain hydroxy fatty acids from waxes of human, bovine and avian tubercle bacillus and leprosy bacillus were injected into experimental animals. The lesions in general are similar to those described, for the waxes and the particles are acid fast, but there is initial and decided necrosis. This reaction in rabbits persists with low-melting human, and particularly with bovine, mycolic acid, however the high-melting human mycolic acid and leprosonic acid are only slowly fragmented into small particles and cause initial but nonpersistent necrosis and the subsequent lesions are small, consisting largely of giant cells that contain vacuoles and are surrounded by a minimal proliferative reaction. The mycolic acids as constituents of the tubercle bacilli may be assumed to contribute to the persistence of lesions induced by this micro-organism, but there is no evidence that they are related to the elective pathogenicity of different types of tubercle bacilli.

Because of the important part calcium plays in body physiology and because of the discordant views, Rai and Kehar¹⁷⁴ undertook a study to determine the absorption of calcium in normal and tuberculous persons under different dietary conditions and also with the addition of ascorbic acid to the diet. The authors draw these conclusions: 1. The serum calcium content of healthy persons with a normal level or of patients with pulmonary tuberculosis with a subnormal level could not be raised, in spite of the feeding of calcium salts for six weeks, if the diet did not contain appreciable quantities of vitamin C. 2. If the diet either contained vitamin C-rich components or was supplemented with ascorbic acid, the serum calcium level increased within a reasonable period. 3. The level of serum calcium rises to the optimum level of normal range.

172 Hinshaw H. C. and Feldman W. H. Streptomycin in Treatment of Clinical Tuberculosis. A Preliminary Report Proc. Staff Meet. Mayo Clin. 20: 313-318 (Sept. 5) 1945.

173 Gerstl B. Tennant R. and Pelzman O. Cellular Reactions to Mycolic Acids. Am. J. Path. 21: 1007-1019 (Sept.) 1945.

174 Rai B. B. and Kehar N. D. Studies on Absorption of Calcium by Normal and Tuberculous Subjects Under Different Dietary Conditions. Antiserum 42: 243-249 (May) 1945.

In 1941 there were fifteen thousand, five hundred and seventy-eight beds in special children's sanatoriums in the Soviet Union for the treatment of tuberculosis of the bone. Krasnobiev¹⁷⁵ states that many other patients were treated at home, under careful medical supervision, and with equally good results. Treatment is essentially conservative—fresh air, sunshine, rest, orthopedic surgery when necessary and diet. School work, music and art are taught the children during their treatment.

The average number of days of stay in a sanatorium for the period from 1918 to 1940 was as follows: spondylitis, 1058; coxitis, 1014; and tuberculosis of the knee joint, 725. The percentages of patients discharged with quiescent disease were as follows: spondylitis, 77.5; coxitis, 85.1; and tuberculosis of the knee joint, 85.0. No mention is made of the amount of operation or of the type of the procedures performed. No follow-up is given.

VIII INFECTIONS OF THE BONES AND JOINTS

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ACCORDING to Elkin and Kelly,¹⁷⁶ a near disaster from hemorrhage of the posterior tibial vessels in the course of the excision of an arteriovenous aneurysm prompted the approach to these vessels by the removal of the upper portion of the fibula, including the resection of the head of that bone where necessary. The rich collateral anastomosis which develops as the result of an arteriovenous communication, together with dilatation of the vessels, including those which perforate the interosseous membrane, demands direct visualization of these vessels and their careful ligation and division. Otherwise the retraction of vascular channels through the interosseous membrane may result in serious or even uncontrollable hemorrhage and necessitate a second incision along the front of the leg or the removal of the fibula in the presence of hemorrhage and at an inopportune time during the course of the operation.

The exposure of the fibula and the method of its removal have been described by Henry, and it was a modification of his procedure which Elkin and Kelly followed, with successful results in 15 instances. The fibula is removed subperiosteally, thus insuring continued stability of the knee joint. Moreover, the peroneal nerve, which may be concomitantly injured along with the vessels, is at the same time exposed and may be explored or repaired without further operative incision.

175 Krasnobiev, T. P. Joint Tuberculosis in the Soviet Union. *Am. Pr. Soviet Med.* 2:270 (Feb.) 1945.

176 Elkin, D. C., and Kelly, R. P. Arteriovenous Aneurysm, *Ann. Surg.* 122:529-545 (Oct.) 1945.

Resection of the fibula for exposure of these vessels is necessary only in their course in the upper portion of the leg. In the lower third they are more easily reached by direct approach along the posterior surface of the tibia on the medial side of the leg.

Careful exposure of the tibial and peroneal vessels in the upper part of their course is necessary in the operative treatment of arteriovenous fistulas in this region. This is facilitated by subperiosteal resection of the fibula, including the head of the bone if necessary. The resected portion of bone is not replaced. There has been no instability of the knee joint following this operation. Fifteen consecutive cases in which this procedure was carried out are presented in abstract.

[ED NOTE—The illustrations are beautiful and profuse. This valuable presentation is the work of two authorities. Rudolph Matas made the statement that the medical personnel at the Ashford General Hospital saw more peripheral vascular surgical lesions in three months than he had seen in fifty years.]

Kelly, Rosati and Murray¹⁷⁷ report that during the past two years an extensive experience with the application of skin grafting to the treatment of osteomyelitis resulting from war wounds has been accumulated at Ashford General Hospital. This procedure is neither new nor original. Lord reported Thiersch grafting of osteomyelitic cavities in 1902. Reid in 1922 published a concise report covering most of the important aspects of the subject. Armstrong and Jarman as well as Quick reported the use, the latter over a period of twenty years, of a technic similar to that employed by Kelly and associates. Neuber, in 1895, and Lord and Beekman, somewhat later, have written of the applicability of pedicle skin grafting to the arrest of this condition.

There have been occasional reports of the successful application of skin grafting in the treatment of osteomyelitis of hematogenous and of traumatic origin for many years. This procedure has failed to gain wide acceptance. It has been successfully carried out by the technic as described for over two years at an Army general hospital. This is a safe form of surgical treatment. Beneficial results can be anticipated in the majority of cases, with loss of little more than skin in the failures. The use of skin grafting in traumatic osteomyelitis has failed to receive the general adoption its effectiveness warrants.

[ED NOTE—This is a welcome presentation of a method advocated many years ago by J. B. Murphy, of Chicago, and J. P. Lord, of Omaha, Neb. I had personal experience with J. B. Murphy in 1911 when he was employing this method. It has been improved chiefly by the addition of chemotherapy.]

¹⁷⁷ Kelly, R. P., Rosati, L. M., and Murray, R. A.: I. Traumatic Osteomyelitis. The Use of Skin Grafts, *Ann Surg* **122** 1-11 (July) 1945.

Bagley¹⁷⁸ chose the knee joint for administration of penicillin because of its size, its accessibility and the expectation of delayed dialization through a synovial membrane, giving prolonged administration of this drug which is excreted so rapidly by all usual methods of administration. He has used this method over eighty times, in a few instances using both knees, one in the morning and the other at night, for several days, 80 per cent of the doses were 100,000 units in 10 cc of sterile water. Some patients had a little discomfort for five or ten minutes immediately following injection. With the use of 2 cc of 1 per cent procaine hydrochloride in the joint several minutes preceding the injection of penicillin patients had no discomfort.

The method Bagley uses is to dissolve the penicillin in 10 cc of sterile water, using a no. 16 needle to perforate the stopper and aspirate the solution. With a 23 caliber $1\frac{1}{2}$ inch (37 cm) needle 2 cc of procaine hydrochloride is injected into the knee joint hugging the patella near the insertion of the tendon. After the contents of the knee are massaged for several minutes with the needle in place, the 10 cc of penicillin is injected through this needle, and an ice bag is placed on the knee for the next eight or ten hours. The sodium preparation made by four different companies was used. The lighter-colored brands seemed a trifle less irritating.

Since writing this article, Bagley has had apportioned to one hospital some deep orange-colored, 100,000 unit penicillin of considerable bulk. This penicillin given intramuscularly is painful, and in the knee joint it is extremely painful and causes swelling. This reaction is evidently due to foreign matter in the preparation and should call for better controlled laboratory methods in its manufacture. Its presence also may harm parenchymatous organs which have been immune to injury from the purer penicillin, which is nearly white. The light lemon-colored penicillin has given little discomfort, and it would seem that the lack of irritation is an index of purity.

Bagley uses isotonic solution of sodium chloride to dissolve the penicillin, every cubic centimeter representing 10,000 units. The high potency, less distensible volume and relatively painless administration with use of an ordinary hypodermic needle, usually without preliminary anesthesia induced with procaine hydrochloride, makes this a practical method of administration, especially outside of the hospital. The knee is slightly flexed and relaxed. The fingers of the left hand press on the inner edge of the patella. The center of the lower edge of the shelving projection of the patella is the mark for entrance into the synovial bursa underneath. A 1 inch (2.5 cm) hypodermic needle will pass through 99 per cent of the synovial sacks at this point. Injection of the extremities, which formerly were treated with hot compresses and

¹⁷⁸ Bagley, W. R. Administration of Penicillin by the Knee Joint Method. *Minnesota Med* 28:205-206 (March) 1945.

sulfonamide derivatives are now treated with penicillin, 10 000 units per cubic centimeter, 10,000 to 100,000 units being injected distal to and in line with the lymphatic vessels and return circulation. The infected area is subjected to a concentrated shower of penicillin such as no general distribution over the body can give, and many times if used before actual necrosis of tissue it will prevent abscess formation. The light lemon yellow solution, penicillin in isotonic solution of sodium chloride, 10,000 units per cubic centimeter, causes little irritation of tissue. Bagley has used 20,000 units in a finger, 40,000 units in the forearm of a 6 year old child and 100,000 units in a leg in which the thigh had been lacerated by the bite of a boar hog. Tetanus serum and injections of penicillin into the knee were also used in this case. The determination of the type of infection is not practical in many of such cases, but Bagley is sure that the motto "use penicillin first" is safe and many times almost miraculous in the curative results, also using large enough doses. With the purer, light-colored penicillin preparation which a number of reliable pharmaceutical houses are putting out, the reactions in the tissue are nothing to extremely mild and it is believed that it is largely due to volume and too rapid infiltration that there is any discomfort. The concentration of 10,000 units per cubic centimeter of isotonic solution of sodium chloride permits the use of large and effective dosage.

According to Flynn,¹⁷⁹ the view that early administration of adequate doses of the sulfonamide compounds is not in itself sufficient to limit the severity of osseous infection finds support in the experience of roentgenologists. In a series of studies, by means of roentgenologic examination of patients under treatment with sulfonamide drugs, it can be shown that the clinical picture is often not very impressive. A condition far different from that which he was led to expect from the absence of clinical signs will confront the observer. The active progression of the disease, as revealed by roentgenograms, will suggest immediate surgical intervention. Since roentgenologic examination will reveal the exact location and extent of the infection, serial roentgenograms would aid greatly in the treatment of patients with suspected osteomyelitis.

The treatment of acute osteomyelitic infections demands adequate operation in combination with use of the sulfonamide drugs.

Good surgical treatment means that every bit of necrotic and infected bone has been removed and that the longitudinal edges of the remaining bone are flat enough to allow soft tissue to fall over and cover the bone. With a correct technic, the end result is good regardless of the type

¹⁷⁹ Flynn, J. M. Symposium: Changes Which Have Resulted from the Use of Sulfa Drug Therapy in Management of Osteomyelitis. New York State J. Med. 45: 493-494 (March 1) 1945.

of chemotherapy which is used postoperatively. The preoperative use of such therapy has its value.

Kross¹⁸⁰ points out that there has recently appeared in the literature an article (*Ann Surg* 119 178, 1944) in which refrigeration anesthesia in surgery is discussed from both the experimental and the clinical point of view. The character of this work on the whole is of such high grade that if all the author's conclusions are accepted without question or challenge it will cause an unnecessary delay in the application of a therapeutic measure that has proved itself beyond any doubt to be of great value in surgical treatment of the extremities. In the body of the paper the statement is made that "cooling per se does not seem to have a beneficial effect on an inflammatory process. While the infected part is cooled there is an inhibition not only of bacterial growth and toxin production but also of the normal tissue response."

The report of a case is published because it is, as far as Kross knows, one in which refrigeration or low temperature treatment was employed for the longest time on record, with the successful preservation of a limb that in ordinary circumstances would have been amputated. It also shows the necessity of continuing with the treatment until the infection is fully and completely overcome.

Dickson¹⁸¹ states that persistent areas of destruction of bone constitute potential sources of trouble. Wilson and McKeever reported 3 patients with acute hematogenous osteomyelitis treated by administration of the sulfonamide compounds without drainage, with subsidence of acute symptoms, in which several months later drainage was established because of persistent local induration. Thick, soft, hyperplastic bone was encountered and granulation tissue was found in the medullary canal when drainage was established. Smears and cultures revealed staphylococci. These findings clearly indicate that such quiescent foci are not really sterile but that they probably harbor dormant bacteria capable of activity.

Treating an abscess of the bone with the sulfonamide drugs and without drainage may be similar to putting out the fire, but letting the ashes remain, only too frequently the ashes have embers which are likely to be fanned into activity by such breezes as lowered resistance or local trauma to the quiescent area. Dickson's observations have convinced him that sooner or later a large percentage of these quiescent foci do become active. Whether penicillin proves to be an agent which is more powerful than the sulfonamide drugs, will completely sterilize

180 Kross I. Low Temperature Therapy for Preservation of Limbs. *J A M A* 128 19-20 (May 5) 1945.

181 Dickson F D. Clinical Diagnosis, Prognosis, and Treatment of Hematogenous Osteomyelitis, *J A M A* 127 212-217 (Jan 27) 1945.

areas of infection only time will tell. Until then the preponderance of evidence is in favor of early drainage of the osseous focus in acute hematogenous osteomyelitis except in the fulminating type with septicemia and pyemia, when the drainage of a single focus, where there are probably others present, cannot be expected to have any helpful effect but will probably do harm.

[ED NOTE—The author is a pioneer in the field. The general practitioner still needs expert advice and help.]

Higley and Rude¹⁸² have had the opportunity of using penicillin in approximately 25 cases of infection of the bone, both acute and chronic, with varying results. They report cases demonstrating the typical changes occurring in infections of the bone susceptible to treatment with penicillin. In general, the period of active infection has been shortened and the clinical results have been gratifying. The summaries of cases and illustration demonstrate what these authors believe to be the typical changes.

The summaries of cases presented represent several types of osseous infection in which Higley and Rude feel that definite improvement followed the use of penicillin. It is their opinion that, in general, the treatment of osseous infections with penicillin has been satisfactory. The response varies in individual cases. In most instances the period of active infection was considerably decreased. In the patients who had a favorable response to penicillin, clinical improvement preceded any roentgenographic evidence of healing. The roentgenographic evidence seen in their cases is as follows: (1) apparent arrest of the spread of the infection, with little or no sequestration of bone and little or no involucrum, (2) positive evidence of healing, in the form of a reactive recalcification of the affected areas, the recalcification appearing throughout the cortex of the bone and approaching the normal architecture of the bone much more closely than does the ordinary involucrum in osteomyelitis (the area of recalcification was of slightly greater density than normal bone), and less resultant end sclerosis than is commonly seen in extensive osteomyelitis which has run the normal evolutionary course, (3) since the progress of the infection in these cases was apparently arrested and the reparative process begun before extensive spread, sequestration and involucrum had appeared.

[ED NOTE—It is difficult for many pediatricians and radiologists and some orthopedic surgeons to determine the difference between progress and progression of the disease. It requires experience and a careful evaluation of general, constitutional and local factors.]

¹⁸² Higley, G. B., and Rude, J. C. Roentgenographic Changes in Bone Infections Treated with Penicillin. *Radiology* 44:115-124 (Feb.) 1945.

Burns, Moss and Brueck¹⁸³ have observed that mycetoma pedis, or madura foot, is a chronic mycotic infection characterized by enlargement and deformity of the foot with the production of multiple abscesses and sinuses which extend deep into the involved tissues. Pus, containing colonies of micro-organisms in the form of granules, is discharged through the sinus tracts to the surface of the skin.

At the present time, it is customary to classify these infections of the foot under the term mycetoma, which by definition has been taken to include all chronic infections which are caused by fungus-like organisms and are associated with the production of granules which appear in the tissues and are discharged in the pus. Because of the distinctive characters of the mycetomas involving the foot, these have sometimes been designated as mycetoma pedis, and in the authors' opinion this designation, which separates the disease from mycetomas located in other parts of the body, is fully justified. Further classification of mycetoma pedis should be followed along two lines: (1) mycetoma pedis due to actinomyces and (2) mycetoma pedis due to true fungi. The latter disease has been heretofore classified as maduromycosis.

Three cases of mycetoma pedis occurring in natives of Louisiana are reported. The findings in 38 cases of mycetoma pedis occurring in the United States and Canada are summarized.

[ED. NOTE—This rare condition is characteristically described. The surgeon always has time to look up the subject if he is alert and keeps it in mind.]

Cooke¹⁸⁴ claims that many of the methods for penicillin assay have been devised and used primarily for testing solutions during the production of penicillin and are not easily applicable to the determination of titers of body fluids in patients under treatment. These have been reviewed by Foster and Woodruff, the classic test of Florey being in commonest use. Of the studies made on body fluids, the method described by Rammelkamp involving the use of serial broth dilutions and a strain of hemolytic streptococcus was used by Rammelkamp and Keefer. Rosenberg and Sylvester have used Foster's method of serial broth dilution with *Staphylococcus aureus* and turbidimetric measurements, while Romansky and Rittman have used a method described by Rake and Jones based on the property of the inhibition of hemolysis of streptococci by penicillin. The procedure described by Cooke is believed to be simpler than some of the other methods mentioned.

183 Burns, E. L., Moss, E. S., and Brueck, J. W. Mycetoma Pedis in Louisiana, United States and Canada. Report of Three Cases Originating in Louisiana, *Am J Clin Path* 15: 35-49 (Feb) 1945.

184 Cooke, J. V. Simple Clinical Method for Assay of Penicillin in Body Fluids and for Testing of Penicillin Sensitivity of Bacteria. *J A M A* 127: 445-449 (Feb 24) 1945.

tioned, is easily applied to the study of body fluids for determination of the titer of penicillin and utilizes only materials and methods familiar to all bacteriologic technicians. In addition it can be readily used for determination of the sensitivity to penicillin of various strains of *Staph aureus* or other organisms. A large number of titrations on blood serum and other body fluids, including spinal fluid, pleural and ascitic fluids and subcutaneous edema fluid, have been performed, and the results have appeared to be consistent. They will be summarized and discussed in a separate report.

The method consists essentially in determination of the lowest concentration of penicillin which will produce complete inhibition of growth of a standard strain of *Staph aureus* on a plain agar Petri plate.

Tests on various strains of *Staph aureus* and meningococci by a method for assay of penicillin in body fluids have shown a considerable variation in sensitivity to penicillin.

[ED NOTE—This is a matter for the laboratory expert. The orthopedic surgeon should keep in mind the fact that it is possible to obtain this information, which in certain situations may be valuable.]

Hamilton¹⁸⁵ notes that the discovery in 1929, by Fleming, of an antibacterial substance obtained from a mold, *Penicillium notatum*, has led to the development of one of the most marvelous therapeutic agents in the treatment of disease in human beings in the history of medicine. Its profound therapeutic value in the treatment of acute osteomyelitis when due to susceptible micro-organisms fully justifies the presentation of this paper. Hamilton draws the following conclusions:

Penicillin is a marvelous and powerful antibacterial agent. Its discovery by Alexander Fleming was more or less by accident. It acts as both a bacteriostatic and a bactericidal agent under certain conditions. Its high antibacterial power is coupled with low toxicity to tissue cells. It is reasonable to presume that since penicillin has become plentiful and the general medical profession has been properly alerted chronic osteomyelitis will be almost a disease of the past.

[ED NOTE—Every reader of this paper or abstract who reflects on his days in the bacteriology laboratory can say (with no pride), "I saw many times what Fleming saw, but I was too stupid to know at what I was looking."]

According to Rooney,¹⁸⁶ in severe dehydration in infants it is at times difficult to restore the fluid balance because of mechanical difficulties of intravenous injections. The blood vessels are small and collapse easily, cutting down on the vessels requires skill and is time

185 Hamilton, J. F. Penicillin in Treatment of Acute Osteomyelitis. *Memphis M. J.* 20: 146-148 (Oct.) 1945.

186 Rooney, E. F. Bone Marrow Intusion with Two Cases of Localized Osteomyelitis. *Arch. Pediat.* 61: 611-616 (Dec.) 1944.

consuming When Tocantins and O'Neill reported the rapidity with which blood and other substances were absorbed from the marrow cavity and later reported successful infusions into the bones of infant, Rooney decided to try their method

The site selected is the proximal end of the tibia or the distal end of the femur Special needles are used, usually the internal needle gage 18 being selected for the smaller infants The extremity is attached to a posterior splint, and the skin over the site selected is surgically prepared The needle is forced through the skin to the periosteum, then with increasing force and rotation the needle penetrates into the medullary canal This is recognized by the definite feeling of decreased resistance and of the needle becoming firmly fixed in the bone Suction is then applied to the needle with a 5 cc syringe filled with isotonic solution of sodium chloride and bone marrow withdrawn into the syringe When the needle is definitely in the medullary canal, it is flushed with isotonic solution of sodium chloride, and an ordinary infusion set containing the fluid is attached If the rate of flow of blood is too slow, it may be diluted with isotonic solution of sodium chloride or by injecting the blood with a 10 cc syringe directly through the needle Success was so uniform that the succeeding one hundred and fifty infusions were given as a hospital procedure

A summary is given of the use of this method in the first one hundred infusions All patients were infants from 3 days to 9 months of age, and their weights ranged from 4 to 14 pounds (1,814 to 6,350 Gm), the average weight being $6\frac{1}{2}$ pounds (2,947 Gm)

Intramedullary infusion in infants is a relatively simple and successful procedure Careful asepsis must be maintained at all times and the needle immediately removed when signs of infiltration of the periosteum or soft tissue are present

[ED NOTE—In certain situations of almost despair this is a lifesaver]

Ryan and his associates¹⁸⁷ anesthetized mice weighing between 20 and 30 Gm by a subcutaneous injection of pentobarbital sodium (0.005 cc of a solution, containing 25.4 mg per cubic centimeter of distilled water, per gram of body weight) The extensor muscles of the thigh were exposed by an incision about 5 mm long, and the appropriate amount of a whole culture of clostridia was injected into the vastus lateralis The belly of the extensor muscles was then crushed with a fine hemostat for about 3 mm of its length After one half hour about 5 mg of the compound to be tested was spread into the wound and the incision was closed with a cotton suture Independent tests

187 Ryan, F. J., Ballentine, R., Schneider, L. K., and Tuck, G. M. Certain Sulfonamide Drugs and Certain Derivatives of Ascorbic Acid in Experimental Gas Gangrene in Wounded Mice *Surgery* 17: 47-53 (Jan.) 1945

showed that the compounds used were not lethal in dosages several times those employed in therapy

The operation itself was not lethal, since all of 14 mice survived when infection was not attempted. In addition, no deaths occurred in 27 cases in which infection was attempted with 0.5 cc of old (twenty-four to thirty-hour) cultures of *Clostridium perfringens*.

It was possible to kill mice by simply dropping the culture into the incision before the muscles were crushed (that is, without injecting the bacteria into the muscle). However, it was thought that the assay would be more rigorous by admitting bacteria into the muscle sheaths of connective tissue. Care was taken to make the operation and infection as constant as possible from experiment to experiment. In two strains of mice the local application of sulfadiazine saved about 60 per cent of the animals infected with *Cl. perfringens*, a significant difference from the controls. Sulfathiazole was also effective against *Cl. perfringens* in one strain of mice but not in others. In one strain of mice ascorbic acid saved about 40 per cent of the animals infected with *Cl. perfringens*, a significant difference from the controls. However, it was ineffective against gas gangrene in other strains. Ascorbic acid, sulfadiazine and sulfathiazole were ineffective against infections caused by *Clostridium novyi*, *Clostridium histolyticum*, *Clostridium sordellii* and *Clostridium septicum*.

Warner and Amluxen¹⁸⁸ found that tests in vitro to determine the sensitivity to penicillin of organisms cultured from patients with infections were useful in the selection of patients suitable for treatment with penicillin and in the regulation of the course of treatment. The concentration of penicillin in the blood of patients receiving injections intramuscularly every three hours with 25,000 units of this substance seldom rises above 0.1 unit per cubic centimeter. Immediately after the administration, intravenously, of 10,000 units of penicillin, the level reaches little more than 1.0 unit per cubic centimeter. Tests in vitro with concentrations of penicillin in these ranges usually give evidence that the organisms being tested are either sensitive or resistant to the levels of penicillin in the blood of patients being treated.

In experiments in which mice were used, a strain of hemolytic *Staph. aureus* that was resistant to penicillin in vitro proved also to be resistant to comparable concentrations of penicillin in vivo.

Kemp¹⁸⁹ observes that in the present war cases of gas gangrene were fewer than they were in 1914 to 1918, but the disease still remains one

188 Warner, H., and Amluxen, J. Comparison of in Vitro and in Vivo Penicillin Resistance of Strain of Hemolytic *Staphylococcus Aureus*, *J. Lab. & Clin. Med.* 30 419-421 (May) 1945.

189 Kemp, F. H. X-Rays in Diagnosis and Localisation of Gas Gangrene, *Lancet* 1 332-336 (March 17) 1945.

of the principal causes of death from wounds. According to MacLennan and Macfarlane (1944) the case fatality rate has been about 50 per cent. Gas gangrene may follow the most trivial wound. In war time anaerobic infections of wounds occur frequently, but in nearly all cases with efficient treatment, the infection is overcome. If attention to the wound is delayed, the organisms may multiply in blood clot or dead tissue without serious ill effects, but once they start to invade healthy tissues the disease may run so swift a course that the patient is dead within a few hours. Every one admits that successful treatment of gas gangrene depends on its early recognition. Even an experienced surgeon finds this difficult, and he must not amputate a limb which can be saved or procrastinate until it is too late to save the patient's life.

During the last war a number of observers noted that it was possible to detect gas in the tissues by means of roentgen rays. In England Dr J. F. Brailsford is the foremost authority. He has stated the belief that it is possible to give an immediate answer to the question "Is there any evidence of gas gangrene?" long before the infection has produced serious clinical signs.

Kemp has made it a rule to reexamine every patient who complains of increasing local pain or discomfort in the tissues around his wound. As a rule, examinations every three hours are sufficient, but in some instances in which the clinical course changes rapidly it may be necessary to examine the patient every hour. If a limb is encased in plaster, a roentgenographic examination is useless and the plaster should be removed.

I do not believe that there are any characteristic clinical signs of early gas gangrene. Many wounded persons show slight signs of general reaction, and a few may be profoundly ill from other causes. The local signs are difficult to assess. I am in complete agreement with authorities who maintain that crepitation is not a reliable guide. As a rule crepitus cannot be felt unless there is gas in the subcutaneous tissues, and Kemp doubts that gas crepitations can be felt in the muscle unless the muscles have already disintegrated. There is no reason why any patient should not be roentgenographically examined. The patient will suffer no harm, for he need not be moved or exposed. If the roentgenographic findings are suggestive, the surgeon need do no more than keep the patient under observation, but if the local condition does not improve or grows worse the examination should be repeated, and serial roentgenographic examinations offer incontestable evidence of formation of gas.

If spreading gas gangrene is established, the radiologist should secure a complete examination of the entire limb or part affected. Some years ago Kemp saw a reputable surgeon amputate three muscles which from the roentgenographic appearances were

infiltrated with gas, without recognizing that the infection was present. He was under the impression that he had eradicated the infection, but it was clear that he had not, shortly afterward the patient died. It is a fact that at operation it may be difficult to recognize that the muscles are infiltrated with gas. They may look normal and there may be no ordinary crepitation, though it may be possible to recognize a difference in texture when the muscles are cut with a knife.

A surgeon need not necessarily remove all the infected tissues, it is sufficient to remove the infected muscles and use chemotherapeutic measures to overcome any infection which has been left behind in the loose cellular tissues.

An account is given of the clinical and roentgenologic features of 331 battle casualties admitted to a hospital in Great Britain. The report deals in detail with the roentgenographic appearances of air in the tissues, local formation of gas and gas gangrene and gives a detailed account of the clinical application of these findings.

O'Reilly¹⁹⁰ has tried to point out that syphilis of the bones and joints may simulate many other conditions and that it should always be kept in mind. Lesions of syphilis of the bones and joints have probably been lessened by the earlier and more thorough treatment of the disease, but they are still present. In all cases if syphilis is present it should be known. A routine Wassermann test should be made in all cases, and a careful history should be taken. A surgeon should always try to elicit the presence of syphilis in the history. Not only may syphilis cause lesions of the bones and joints, but it may complicate other lesions. Its treatment should be early and prompt.

Potassium iodide and mercury seem to act more rapidly than the arsenicals, but care must be used to see that the patient is given the proper constitutional treatment. For this reason orthopedists and syphilologists should closely cooperate.

Altmeier and Reinecke¹⁹¹ point out that penicillin has revolutionized the management of acute hematogenous osteomyelitis. The spectacular control of bacteremia, the bony infection and the metastatic visceral infectious complications has produced a radical reduction in morbidity as well as mortality rates. This control of the infection has been so effective that emergency surgical decompression of the area of involved bone has not become necessary except in fulminating conditions. Instead, the required operation has usually been limited to incisions and drainage of abscesses developing in soft tissues and to the

190 O'Reilly A. Syphilis as It Affects Orthopedic Surgery, *Urol & Cutan Rev* 49 243-245 (April) 1945

191 Altmeier W A and Reinecke H G. Roentgenographic Interpretation of Acute Hematogenous Osteomyelitis Treated with Penicillin. *Am J Roentgenol* 54 437-438 (Nov) 1945

removal of selected large and unabsorbed sequestrums. The disfiguring sequelae, such as deformity, lump, draining sinuses or ankylosis of adjacent joints, have been largely eliminated. Likewise, a careful study of the patients treated with penicillin has forced these authors to modify their earlier conceptions and interpretations of the roentgenographic changes occurring in acute hematogenous osteomyelitis.

In twenty-seven months they observed the results of treatment with penicillin in 52 cases of acute hematogenous osteomyelitis. The group included 44 cases of acute hematogenous osteomyelitis of the major long bones, in some of which there was also involvement of the flat bones of the pelvis. In addition, there were 4 cases with involvement of the pelvic bones only. The responsible etiologic agent was determined in every instance but 4 and was found to be hemolytic *Staph aureus* in 42 cases, nonhemolytic *Staphylococcus albus* in 3, hemolytic streptococcus in 1 and *Pneumococcus* type III in 1.

Although the roentgenogram is of little or no value in making an early diagnosis of acute hematogenous osteomyelitis, it is of definite value in the recognition of the process after ten to fifteen days beyond the onset. A succession of changes occurring in bone has been described in the patients treated adequately with penicillin and have been interpreted as a measure of the process of spontaneous repair and not as an indication of further extension of the osteomyelitic process, as has been generally assumed. The spontaneous removal of necrosed bone has been followed by recalcification and healing of the involved area.

Kirby¹⁹² states that an enzyme-like substance capable of destroying penicillin was produced from *Escherichia coli* and certain other saprophytic and commensal bacteria in 1940, but attempts to extract a penicillin inactivator from sensitive or resistant staphylococci were unsuccessful. More recently, acetone-ether extracts of paracolon bacilli which were more effective inhibitors of penicillin than were extracts of *Esch coli*, were prepared.

In this country, it was found that clarase, a diastatic enzyme preparation, readily destroyed penicillin, and this substance is now used widely for sterility tests during production of penicillin. Apparently the ability to inactivate penicillin is possessed by only certain *Asch* clarase, and this action is attributed in a later publication to the presence of bacterial products, especially of *Bacillus subtilis* and related gram-positive organisms.

A penicillin-destroying staphylococcus has been found contaminating a culture of *Aspergillus flavus*, and independently in Kirby's laboratory.

¹⁹² Kirby, W. M. M. Properties of Penicillin Inactivator Extracts of Penicillin-Resistant Staphylococci, *J. Clin. Investigation* 24:170-174 (Nov.) 1945.

a highly potent inactivator of penicillin has been extracted from penicillin-resistant staphylococci obtained from clinical sources Kirby presents details of the extraction and properties of this substance This highly potent inactivator of penicillin was extracted from seven strains of *Staph aureus* which were naturally resistant to penicillin, seven sensitive strains did not produce a penicillin-destroying substance The resistant bacteria were not lysed but were by no means completely resistant to the bacteriostatic action of penicillin This differentiation between resistance to lysis and resistance to bacteriostasis is discussed elsewhere

It is of fundamental importance to determine whether the several inactivators of penicillin so far described are identical or whether penicillin can be destroyed by substances whose chemical structures are unrelated Properties of the known inactivators of penicillin are summarized Presumably they are all products of bacterial metabolism, but whether they are produced by all penicillin-resistant organisms has not yet been definitely determined The differences in properties are relatively superficial and possibly largely due to differences in technical methods Further chemical studies are necessary for final clarification

Myers and Lenahan¹⁹³ claim that because of the chronicity of osteomyelitis recovery in their case may have been apparent only, and due instead to a spontaneous remission However, this seems unlikely in that there was no fever or pain or other evidence of the disease in more than seven months, the patient gained weight and otherwise improved steadily, and roentgenograms indicated that healing of the bone was taking place

The question arises as to whether the penicillin was contributory to the recovery in view of the demonstrated complete fastness of the organism recovered from the draining sinus after the second course of penicillin That it was seemed probable because the patient received no specific treatment other than penicillin, and spontaneous recoveries of untreated patients with chronic osteomyelitis are uncommon

Recovery followed the intramuscular administration of two courses of 1,000,000 units (0.6 Gm) and 2,500,000 units (1.5 Gm) of penicillin five months apart in a case of osteomyelitis of a femur and ilium, of thirty months' duration, together with chronic otitis media in an 11 year old boy Repeated prolonged heavy courses of sulfathiazole administered previously had been ineffective Cultures of staphylococci recovered from a draining sinus immediately following the second course of penicillin were fast to penicillin in vitro Recovery in spite

193 Myers, W. G., and Lenahan, F. A Case of Osteomyelitis Treated with Penicillin with Unusual Bacteriologic Findings *Ohio State M J* 41:422-425 (May) 1945

of the development of this fastness to the drug is attributed to an associated concomitant loss either of virulence of the organism or of insusceptibility to the antibacterial action of blood or both. The fastness of the organism to penicillin largely disappeared after several months of storage at 3 to 5 C.

During the first course of penicillin, chickenpox appeared on the sixth hospital day in spite of the drug. This is another instance of the ineffectiveness of penicillin in many virus infections.

An average of 48 per cent of the daily dose appeared in the urine; the range was 22 to 84 per cent. The concentration varied between 9 and 38 units per cubic centimeter of urine, depending somewhat on the volume excreted. Penicillin had ceased to appear in the urine within twenty-four hours after the last intramuscular dose.

As Professor Fleming has remarked, it would be a most unusual accident if the first successful antibiotic would prove to be the best one. Myers¹⁹⁴ notes that at present there is a widespread search for other antibiotics which will be effective against pathogenic organisms that are insusceptible to penicillin, that will be more easily produced, more stable, that can be taken by mouth or that can be readily synthesized. Among the many which have been described are gramicidin, tyrothricin, streptothricin, streptomycin, actinomycin, clavacin, ghotoxin and penatin. However, most of them do not combine the lack of toxicity with the effectiveness possessed by penicillin. Of particular interest is streptothricin, since it is reported to be effective against the organisms that are responsible for typhoid fever and bacillary dysentery, an important group of gram-negative pathogens against which penicillin is entirely ineffective.

Wood¹⁹⁵ calls attention to the fact that in North America maduro mycosis (madura foot, or mycetoma) has been a rare and little known disease, in contrast to India and the Dutch East Indies, where it is prevalent and well recognized. Because larger numbers of men from the United States were exposed to infection by the fungi which give rise to maduromycosis, he reports a case recently seen in a United States naval hospital in which the condition, of the melanoid variety, involved the left ankle of a Filipino 40 years of age. The mycotic lesion had been present for at least seven months. Early in its course the overlying skin had ulcerated for a short time, but it subsequently healed. On surgical dissection the lesion was found to be circumscribed and subject to complete excision. No distant lesions were evident. Etiology is briefly discussed.

194 Myers W G. Penicillin. A Potent New Chemotherapeutic Agent. *J. Sc.* 44 277 (Nov.) 1944.

195 Wood D A. Maduromycosis of the Ankle. Report of a Case. *California & West Med* 62 119-121 (March) 1945.

Symmers¹⁹⁶ reports that up to 1945 twenty-two species of fungi belonging to ten genera and four families had been implicated in the production of the various types of maduromycosis. In spite of this multiplicity of causes, the different types clinically may resemble one another closely, and in some instances they may also resemble actinomycosis, especially if the latter disease is confined to a lower extremity, as is maduromycosis in many cases. Clinically, cases of maduromycosis may be divided into three groups. In all of them the lesions are limited to the part which was originally infected, as the foot, hand, knee, neck or face.

Phialophora jeanselmei when injected subcutaneously into rabbits produces solitary nonulcerative nodules which histologically are specific and are closely comparable to the nodules in that form of maduromycosis in human beings which is caused by the same fungus.

Symmers and Sporer¹⁹⁷ also discuss maduromycosis. Maduromycosis, or mycetoma, madurosis or, as it is perhaps most widely known, Madura foot, is a fungous disease which was first adequately described by Vandyke Carter. He encountered it as an endemic infection in and around the city of Madura in the Madras Presidency of India. Since then it has been recognized in different parts of the world, including other districts in India, Ceylon, Cochin China, the Netherland East Indies, Africa, Argentina, Cuba, the United States and Canada. It occurs oftenest in arid tropical or subtropical climates among men engaged in agricultural pursuits who are in the habit of working barefoot. The disease is seldom seen in women. One of the commonest modes of infection is through the pricks of thorns. Unlike actinomycosis, which is most frequently found in cattle and swine, maduromycosis is apparently confined to human beings.

The case presented in this report appears to be the first example of maduromycosis of the hand to be described in the United States, the second on the North American continent and the fifth thus far recorded. It is probable that additional cases have been observed in this and other parts of the world but not recorded.

Experimental staphylococcic infections in animals which simulate natural-occurring infections in human beings are difficult to produce, according to Kempf and Herrick¹⁹⁸. In order to evaluate the recently

196 Symmers D. Experimental Reproduction of Maduromycotic Lesion in Rabbits. *Arch. Path.* **39** 358-363 (June) 1945.

197 Symmers, D., and Sporer A. Maduromycosis of the Hand, *Arch. Path.* **37** 309-318 (May) 1944.

198 Kempf J. L., and Herrick, J. A. Effect of Penicillin on Experimental Staphylococcus Osteomyelitis in Rats. *Proc. Soc. Exper. Biol. & Med.* **58** 100-102 (Jan) 1945.

introduced chemotherapeutic agents it would be desirable to have access to readily reproducible *in vivo* procedures. The purpose of this study was to develop methods for the production of chronic staphylococcal infections in mice and determine the value of penicillin in the treatment of such infections.

The results indicate that penicillin has definite value as a systemic therapeutic agent for staphylococcal osteomyelitis in rats and, further, that rats are suitable animals for studying the course of experimental osteomyelitis and the evaluation of therapy in this disease.

Osteomyelitis was produced experimentally in white rats by inoculation of the bone marrow of the tibia with *Staph aureus*. About twenty-one days were allowed for the development of typical lesions. One group of 14 animals was treated by the subcutaneous injection of 600 units of penicillin every two hours for nine days. Six of these apparently recovered during the course of the treatment. In a second experiment 13 animals were each given 900 units of the drug every hour for an equal period. Again six of the lesions were found to be healed at the termination of the injections. Of a total of 25 untreated controls, only 1 animal showed evidence of recovery.

Mayers¹⁹⁹ reports a case of regeneration of bone following osteomyelitis. The patient was a policeman who was bitten on the middle finger of his left hand by a man whom he was arresting. Striking another person on the teeth by accident would seem to be less risky than a deliberate bite, but even such accidental contacts are not an infrequent source of infection, and there have been cases in which a mixed aerobic infection from organisms of the mouth resulted. The latter was true in this case. Pyogenic organisms, spirilla and anaerobes were all present as the infection progressed.

The policeman was admitted to the hospital the morning after the wound was received. The following day the finger was incised beneath the nail, liberating a quantity of foul, purulent material. Drainage continued to be rather profuse for some time. The destructive process was advancing. Twelve days after the patient was admitted to the hospital the roentgenologist's report showed almost complete destruction of the middle portion of the phalanx and tip, with moderate advanced invasion of the distal three-fourths of the middle phalanx and involvement of the distal joint, the soft tissues still showed considerable thickening.

Thus, it appears that the infection was advancing according to rule from the distal anterior closed space by way of the nutrient foramen into the medullary cavity with osteomyelitis as the result. There was

¹⁹⁹ Mayers, L. H. Bone Regeneration Following Osteomyelitis. *Surg. Gynecol. & Obstet.* 17: 463-471 (March) 1945.

spread is to the flexor subtendinous space of the base of the distal phalanx and into the joint cavity and continuing to the middle phalanx, with probably entry to the tendon sheath. In the case under discussion there was involvement of (1) soft tissue, (2) bone, (3) joint and (4) tendon.

The outcome of such a destructive and progressive osteomyelitis will depend on a number of things—the type of the organisms present, the age and condition of the patient and, probably most important of all, the treatment.

The mixed infection, particularly one including anaerobes, is more serious than one involving a single organism. A child has a better chance to combat the infection and to obtain regeneration of bone than an older person. The results in the case of the policeman, however, indicate that his age did not work against him. His recuperative power was one of the factors that gave the case a lively interest.

Jern and Meleney²⁰⁰ note that the most important groups of bacteria from the point of view of surgeons are and always have been the streptococci, the staphylococci and the gram-positive spore-forming anaerobes of the gas gangrene group. It is generally recognized that the sulfonamide drugs have taken the terror out of hemolytic streptococcic infections and have reduced the incidence of septicemia from this organism to almost negligible proportions. It was hoped that they would be equally potent against the other two groups, but experience has shown that, while conditions in individual cases may respond promptly and remarkably, in the great proportion of cases they resist sulfonamide treatment.

Penicillin is outstanding in saving chick embryos or prolonging life after inoculation with virulent hemolytic *Staph. aureus* cultures in doses which regularly kill controls in twenty-four hours. In this respect it is superior to staphylococcus bacteriophage or staphylococcus antitoxin or vioform, or carboxymethoxylamine or sulfathiazole or another antibiotic derived from *Bacillus T*.

The increasing availability of penicillin and its demonstrated efficiency in the clinical treatment of staphylococcic infections relegates the use of staphylococcus bacteriophage in these infections to a place of second rank and only to be considered in cases in which penicillin fails.

The efforts of Jern and Meleney to produce a more highly potent staphylococcus phage by the use of egg embryos has not been successful. The difficulties of developing a commercial phage of high potency and

²⁰⁰ Jern, H. Z. and Meleney, F. L. Superiority of Penicillin over Bacteriophage, Sulfathiazole and Certain Other Antibacterial Substances. *Surg. Gynec. & Obst.* 80: 27-34 (Jan.) 1945.

prolonged activity still remain. Further studies are indicated in the field of antibiotics for the staphylococcus and other organisms. Egg embryos offer a reliable medium for the appraisal of antistaphylococcus agents and other antibacterial substances.

Jern and his associates²⁰¹ point out that the treatment and prevention of chronic staphylococcic infections, particularly of recurrent furunculosis and axillary abscesses, have always been one of the major problems confronting general practitioners and surgeons. It is known that the use of vaccines, various chemicals and sulfanilamide derivatives, roentgenologic and ultraviolet irradiation, autochemotherapy and many other methods of treatment have not fulfilled their expectations. It is natural, therefore, that the discovery of staphylococcus toxin and its ability to produce antitoxin attracted wide attention as a possible method of treatment and prevention of staphylococcic infections.

The discovery of Burnet that staphylococcus toxin could be detoxified by solution of formaldehyde without the loss of its antigenic power greatly simplified the matter of immunization. This led to the wide clinical use of a detoxified toxin known in different countries as toxoid or anatoxin.

The problem of recurrent staphylococcic infections in the form of furuncles and carbuncles frequently plagues general practitioners and surgeons. It is well known that certain persons are generally resistant and others generally susceptible to infections. Others who have been resistant suddenly become susceptible. No reliable test has been discovered to measure either the resistance or the susceptibility to staphylococcic infections, although many attempts have been made to find such a test. Normal persons do not have a high antihemolysin titer and there must be some other element of immunity which is responsible for natural resistance. Many immunologists believe that it resides in the phagocytic power of the leukocytes, but this cannot be conclusively demonstrated.

The treatment of 93 patients with recurrent furunculosis and axillary abscesses with pepsin digest Staphylococcus toxoid (Lederle Laboratories, Inc.) resulted in a complete recovery of only 38 per cent. In the other 62 per cent, recurrences developed within one year after the end of the treatment. Of the 70 patients who received at least six injections of pepsin digest toxoid, the antihemolysin titer in 52 cases (74 per cent) ranged between 1 and 3 units and in 18 (26 per cent) it was between 3 and 10 units. Out of 40 patients with recurrent furunculosis and axillary abscesses treated with Staphylococcus toxoid

201 Jern H. Z., Caprarro C. and Melenev, F. L. Value of Staphylococcus Toxoid in the Treatment and Prevention of Chronic Staphylococcus Infections. *Surgery* 17: 363-378 (March) 1945.

(Connaught Antitoxin Laboratory) complete recovery occurred in 31 (78 per cent). In 9 others (22 per cent) recurrences developed within one year after the end of the treatment. In 5 of the cases the recurrences were milder than the conditions prior to the treatment. Of 29 patients tested after seven or more injections of Connaught toxoid, the antihemolysin titer of the serums in 23 (79 per cent) ranged between 4 and 12 units, only in 6 (21 per cent) was it 3 units or less. These are statistically significant differences. The antihemolysin test is not a strict measure of immunity, for there are exceptional cases in which the patient has a rise in titer and has recurrences and others in which the patients have no rise and yet seem to be cured. There may be some other immune factor which does not run strictly parallel with the antihemolysin titer which is of major importance but cannot be measured.

Staphylococcus toxoid made from toxigenic strains is able, by means of repeated injections, to increase the antihemolysin titer of the blood and to lessen significantly the incidence of recurrence of furuncles and carbuncles.

Keefe²⁰² expresses the belief that since many recent publications describing the effects of streptomycin have created so much interest and so many demands for it the medical profession and public should be informed of the arrangements now in effect to adjust the present limited supply to a program of clinical investigation.

The Committee on Chemotherapeutics and Other Agents of the National Research Council, at the request of the Civilian Production Administration and the Streptomycin Producers Advisory Committee is supervising an investigation of the clinical usefulness and possible toxicity of streptomycin. The primary interest of the committee in streptomycin is to determine its effectiveness and toxicity in certain infections which are not susceptible to treatment with sulfonamide drugs, penicillin and other therapeutic agents.

The introduction of streptomycin to the medical profession is so recent that much remains to be learned concerning limitations of its usefulness, methods of administration dosage and toxicity. Most of the information obtained so far has issued from military and civilian hospitals as a result of clinical investigations which have been carried out under arrangements between producers of streptomycin and individual clinical investigators. Similar studies are being continued and amplified by the Committee on Chemotherapeutics and Other Agents of the National Research Council, and a fraction of the streptomycin is now being allocated to the committee for these purposes. It is placed

202 Keefe, C. S. Official Statement Concerning Streptomycin. I. A. M. N. 131:31 (May 4) 1946.

in charge of the chairman for distribution to those hospital physicians most competent to obtain the vitally needed information

Diseases which are to be investigated with streptomycin by the committee are gram-negative bacillary infections of the genitourinary tract resistant to the sulfonamide drugs, gram-negative bacillary infections with bacteremia, *Hemophilus influenzae* infections including meningitis, pneumonia, diseases of the middle ear and laryngotracheitis, pneumonia caused by Friedländer's bacillus (*Klebsiella pneumoniae*), typhoid, *Salmonella* infections (paratyphoid), acute brucellosis with bacteremia, tularemia, and bacterial endocarditis due to gram negative bacilli. Diseases which are not being investigated by the committee at present are chronic idiopathic ulcerative colitis, lupus erythematosus, acutus disseminatus, leukemia, cancer, fever of unknown cause, rheumatic fever and rheumatoid arthritis

Foley²⁰³ observes that osteomyelitis is one of the most tragic of diseases which can affect the children of any nation, and the number of adults who are primary sufferers from this disease is also surprising

There are certain points about the causation of osteomyelitis which are perhaps not well known. First, the history given by the patient or their relatives is often misleading with deliberate questioning it is found that the initial cause of the illness, a carbuncle, boil or infection of the respiratory tract, has been forgotten and healed three to four weeks before the identical organism produced the train of symptoms known as acute osteomyelitis

Second, persistent septicemia of an apparently unknown origin is more likely than not to be due to osteomyelitis, and, alternatively, if septicemia is permitted to persist it will more probably than not give rise to osteomyelitis. In 6 cases, had penicillin not saved the life of the patient and given time and opportunity for the feeding focus to be discovered in one of the bones, the patient would have died of the cause of his malady unrecognized, for it is not usual for every bone in the body to be examined in the postmortem room by the pathologist

Dr J. Trueta reported the results in a series of 30 patients with acute osteomyelitis treated with penicillin over a period of eight months at the Wingfield Morris Orthopaedic Hospital

A standard routine was adopted. Patients admitted without a focus were treated by penicillin alone, those with abscess or focus were treated with penicillin and with surgical treatment which included drilling of the bone and primary suture after evacuation of as much pus as possible. Immobilization of the affected part was also used. The results were encouraging. There was no death in the series. In no case did a metastatic focus or a local invasion of the joint develop

203 Foley, W. B. Treatment of Acute Osteomyelitis with Penicillin. *Trans. Roy. Soc. Med.* 39: 371 (Feb.) 1946

after admission. Seven patients were suitable for treatment with penicillin without operation; the remaining 23 required surgical treatment. Of these, 2, early in the series, were treated by aspiration alone and had extensive damage to the bone. One was readmitted ten months after onset, with an abscess connected with the involucrum. Of the twenty-one wounds, eighteen healed without sinus formation, one (unsutured) became secondarily infected and required drainage after healing and two with extensive damage to the bone on admission developed sinuses. Four sinuses persisted, two from undrained and two from drained abscesses. There was normal function in 28 of the 30 cases. The exceptions were a patient with osteomyelitis of the femur admitted with septic arthritis of the knee, in which the knee range was 5 to 90 degrees, and a patient with osteomyelitis of the humerus, of fulminating type, admitted thirty-six hours after onset, with involvement of the whole shaft of the humerus; there was full range of movement at the joints, but she was still in hospital thirteen months after onset, with a persistent sinus.

The results of the treatment of acute osteomyelitis with penicillin were so good that it is fair to say that the disease has been altered and that a new standard is now needed for the results. It is no longer right to congratulate oneself on a low rate of mortality, metastases, involvement of the joints and sinuses. There should be no such rate. Improvements will be obtained if patients can be admitted earlier, and now that it is known that there is a cure for the disease if it is treated early, physicians should admit patients for treatment earlier than they have done hitherto, one should no longer wait for the appearance of an abscess. Early stages can be treated by penicillin alone, and the patients may leave the hospital, perfectly normal, after three weeks. For later stages, however, surgical treatment is still important, and it should include drilling of the bone and primary suture.

Foley concludes that penicillin therapy has reduced the mortality of acute osteomyelitis from 25 per cent to about 4 per cent, that if penicillin is used during the first few days of the disease complete resolution may occur, that, if resolution does not occur, then immobilization of the affected limb should be prolonged in patients with extensive involvement of the bone, and if operation is required secondary suture can be safely done at the end of a week. There is no longer any justification for the closed plaster treatment in this disease.

According to Niebauer,²⁰⁴ malignant degeneration of the skin which lines sinus tracts is not always readily recognized as a complication of chronic osteomyelitis. The carcinomatous lesions are in some instances large, cauliflower-like epitheliomas extruding from the sinuses, however

204 Niebauer I I Development of Squamous-Cell Carcinomata in the Sinus Tracts of Chronic Osteomyelitis. *J Bone & Joint Surg* 28: 103-112 (Jan) 1946

the more insidious variety, often unsuspected until the development of metastases, exists deep in the epithelized cavities. Stewart, Obermayer and Woolhandler reported a case in which cutaneous metastases occurred after the amputation of a thumb for chronic osteomyelitis. The pathologist's examination of the amputated phalanx then revealed the primary epithelioma.

Henderson and Swart reported on 5 cases of malignant lesions among 2,396 cases of chronic osteomyelitis. Benedict found 12 such cases among 2,400 cases of chronic osteomyelitis. The epithelization of draining sinuses in cancellous bone is well recognized. Milgram claimed that this is one cause of persistent drainage.

Bereston and Ney, in reviewing the literature, found that malignant changes usually developed in men between the ages of 40 and 60 years who have had draining sinuses of from twenty to fifty years' duration. The tibia, the femur and the bones of the foot are oftenest involved.

Amputation is usually the best method of treatment. Because of the existing infection, it is logical to perform a guillotine amputation as close to the involved area as may be done with safety. If enlarged lymph nodes are present and do not subside after the amputation they should be excised, since they may contain metastatic carcinoma. Roentgen therapy may then be initiated. The prognosis following amputation is good, since there are few early metastatic lesions.

These 2 cases clearly illustrate several points in the diagnosis of squamous cell carcinoma arising from epithelized, chronic sinuses of bone. Both patients were in the age group in which this complication is found oftenest. In neither patient was the correct diagnosis obvious on clinical examination. The skin at the edges of the sinuses appeared irritated from the constant drainage. Microscopic examination of the tissue first removed showed only chronic inflammation. In fact in case 1, an epithelioma on the unhealed amputation stump led to reexamination and the discovery of the tumor in the amputated portion. The specimen obtained by curettage in case 2 showed no epithelioma. Thus in suspected cases it is well for the surgeon to perform a biopsy under direct vision in the operating room and to select several suitable specimens for microscopic examination.

Both patients had tolerated their osteomyelitis well for many years. Their complaints of pain and profuse foul discharge were of recent months' duration only. The first patient had a pathologic fracture of the femur and bleeding from the sinuses in his thigh. These findings are characteristic of carcinoma, developing in an epithelized osteomyelitic sinus tract.

Roentgenograms of these 2 patients, although not diagnostic themselves, presented a provocative finding of small areas of density in the sclerotic bone surrounding the cavities, a picture which is the result of extension of the carcinoma.

The results obtained in cases of chronic osteomyelitis treated with penicillin reported by Keir²⁰⁵ were a great improvement over those previously gained in his unit without penicillin. The general condition of the patients after operation was much better than in the prepenicillin days, the nurses in the wards were particularly impressed by this factor.

In the only 3 cases in which the lesions did not heal penicillin-resistant staphylococci were present after operation, and these lesions were still unhealed many weeks afterward despite the fact that the staphylococci again became sensitive to penicillin. It appears possible that during the period of resistance to penicillin the organisms cause further infection and destruction of bones.

It was shown that once the staphylococci were eliminated the penicillin-resistant group, *Escherichia coli*, *Pseudomonas pyocyanea* and *Proteus vulgaris* succumbed in a few weeks to such preparations as a mixture of acriflavine and sulfathiazole powder, "U F I" powder (a preparation of urea and iodine) and alternate dressings of the "U F I" powder and eusol (an antiseptic solution containing calcium chloride, calcium borate and hypochlorous acid compounds).

Local surgical treatment in conjunction with use of penicillin offers a definite hope of clearing the process in many cases of chronic infection of the bone. The local surgical treatment must be adequate and care must be taken to remove all infected tissue and sequestered bone; otherwise the local administration of penicillin is valueless.

There has been some doubt about the value of penicillin in the treatment of chronic sepsis of the bone. In this series, however, in 23 out of 26 cases the lesions healed, and they have remained healed for an average period of four and a half months; 19 of the patients have returned to work, including several doing hard manual labor. It appears, therefore, that penicillin has an important part to play in the general scheme of treatment of chronic osteomyelitis.

Agerholm and Trueta²⁰⁶ report that penicillin has changed the course and prognosis of acute hematogenous osteomyelitis. It is no longer enough to compare the results with and without penicillin; a new standard is needed. Physicians must no longer congratulate themselves that any series shows a low mortality rate, a low rate of metastatic infection, a low rate of involvement of the joints or a low rate of sinuses. It should be deplored that there is any such rate. It is known that if a patient comes to treatment early enough it is possible with penicillin alone to cause complete resolution of the lesion and the patient may be discharged from hospital without any disability, perhaps at the end of

205 Keir D. M. Penicillin in Chronic Osteomyelitis. *Lancet* 2:42 (Jul. 14) 1945.

206 Agerholm M. and Trueta I. Acute Haematogenous Osteomyelitis Treated with Penicillin. *Lancet* 1:877-881 (June 15) 1945.

three weeks. The only regret in these cases is that so often there is no proof of the diagnosis, although there may have been no clinical doubt on admission.

In patients who come to treatment later, when there is already damage to the bone and abscess formation, there is some difference of opinion on the appropriate treatment. Agerholm and Trueta treated 2 patients of this type with penicillin and immobilization alone. They found that the systemic infection was controlled but that even after all general disturbance had subsided, there remained local swelling and that roentgenographic changes spread from the original small focus at the metaphysis to involve half the shaft of the femur. They therefore abandoned this method of treatment and combined penicillin treatment with operation, which included drilling of the bone. The results were as good as they had hoped, the systemic response was more immediate, and there was no spreading roentgenographic change. Repair began in the area first shown roentgenographically to be involved; there was no spread of the disease to a neighboring bone or joint. The results contrasted so favorably with those of the undrained or undrilled infections that they did not feel justified in withholding operation from any more patients of this type. One patient was admitted eight weeks after onset from another hospital, where she had had two weeks' adequate penicillin therapy and incision of abscesses without drilling. She showed the same extensive damage to the bone seen in undrained infections, she also had severe anemia (hemoglobin content 42 per cent). Her general condition contrasted strongly with that of patients in the authors' series, though there was no evidence that the infection had initially been severe.

Two well defined groups of patients were distinguished: (1) those admitted before the bone was seriously damaged and before pus had formed and (2) those admitted with an abscess already present. Group 1 could be treated successfully by systemic penicillin alone provided the course was sufficiently long and intensive, the condition might resolve without any roentgenographic changes in the bone, 7 out of 30 (1 in 4) patients admitted were suitable for this treatment. Group 2 must be treated surgically as well as with penicillin, and surgical treatment must include release of pus in the bone by drilling, after this, primary suture is safe and advisable to prevent secondary infection. In patients in group 2 not treated by operation as well as penicillin a spreading decalcification of the bone developed, the area of which increased from one to five months. Workers at other centers have confirmed this. In this series there was no death, no involvement of the joint, no secondary focus after admission. At the end of eighteen months 4 patients had a sinus but 2 of these were nearly healed, 28 patients had normal function, 1 patient admitted with septic arthritis of the knee had a limited range of movement, and 1 had a sinus which kept her in bed.

The importance of surgical drainage in these cases is discussed

One case of infection with a penicillin-resistant organism was encountered early in this series but was not included in the series because at the time the authors did not have sufficient penicillin for adequate treatment of the patient. It was four times as resistant as the normal staphylococcus, it would have required at least 400 000 units of penicillin in twenty-four hours for bacteriostasis. The case serves as a reminder that the sensitivity of the organism must always be tested.

IX CHRONIC ARTHRITIS

Prepared by

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NO OUTSTANDING discoveries have appeared in regard to chronic arthritis. There have been some additional studies on etiology. Gold therapy has been subjected to a somewhat more critical analysis, and the toxicity especially has been stressed. Reiter's syndrome has been frequently recognized particularly in men in the Army. Here it has frequently been confused with gonorrheal infection until bacteriologic studies giving normal results have questioned the diagnosis. Some excellent papers on general treatment have appeared. There has been greater interest in the surgical therapy of chronic arthritis particularly osteoarthritis.

ETIOLOGY

A large number of trivial injuries occurring during a day's activities are regarded by Cecil²⁰⁷ to be of importance in the pathogenesis of rheumatoid arthritis, particularly psychic trauma and strain. Poor posture is one of the factors causing daily mild trauma. When pains develop, rest and mild sedation may be enough. Often if the condition is not serious or likely to increase one must endure it philosophically. Proper readjustment of the environment will often correct what is not arthritis.

Edstrom²⁰⁸ has observed that parts of the body which are not used are little involved by arthritis. Subcutaneous nodules appear where pressure and weight are borne. In arthritis after mechanical or functional damage the proliferative component becomes dominant.

Flind and Barber²⁰⁹ studied 120 patients with articular pains at the Rheumatic Center of the Royal Air Force. Psychologic investi-

207 Cecil, R. L. Environmental Factors in the Etiology and Pathogenesis of Rheumatism. *N. Clin. North America* **29**: 566-570 (May) 1945.

208 Edstrom, G. Relation Between Trauma and Arthritis. *Acta med. Scandinav.* **111**: 150-171 1942.

209 Flind, I. and Barber, H. S. Psychogenic Basis of Some So Called Rheumatic Pains. *Quart. J. Med.* **14**: 57-74 (April) 1945.

gation was carried out on 42. There was a suggestive history of neurosis in 29 and a morbid concern over health in 26. There was often a family environment of chronic illness. In 8 there was a frequent change of employment. There was little evidence of rheumatic infection on physical examination. Hysterical reactions were found in 17, anxiety states in 22 and depressive states in 3. The diagnosis was usually difficult. Short psychiatric treatment was given in most cases. About 50 per cent of these patients were invalided. The authors questioned what name to give the conditions in these cases. They labeled each condition by its psychiatric diagnosis.

A characteristic basic vascular tone was found in patients with rheumatoid arthritis by Naide and associates.²¹⁰ There is consistently a high grade of basal vascular tone. Fifteen ambulatory patients with rheumatoid arthritis were studied. The peripheral vessels were constricted easily. The decided vascular tone may predispose to rheumatoid arthritis. The authors felt that this is a possible therapeutic lead and that attempts to produce reflex vasodilatation might be of benefit.

Sjövall²¹¹ studied 116 cases of chronic polyarthritis in women and 47 nonarthritic women as controls in an attempt to find a relationship between sexual function and arthritic disease. Determinations of chronic gonadotropin levels were made in 102 women, estrone levels were measured in 14, both were measured in 3. Sjövall found that one third of the arthritic women under 40 had ovarian insufficiency. A relationship with chronic arthritis was observed in one fourth of them. The author postulated that ovarian insufficiency led to lessened follicular production but decreased estrone levels could be present with normal ovarian function. In pregnancy production of estrone was greatly increased. He found improvement in the arthritis in pregnancy in about one half of the cases.

[Ed. NOTE—There was no mention of treatment with ovarian hormones.]

Admitting that the infectious theory for the causation of arthritis is unproved, Ensign²¹² feels, however, that there is a formidable mass of evidence in favor of it in rheumatoid and in mixed forms of arthritis. Arthritis does not clear up on the removal of focal infection alone. The author advises complete examination of the mouth even when all other

210 Naide M, Saven A and Comroe B I. Characteristic Vascular Pattern in Patients with Rheumatoid Arthritis. *Arch Int Med* 76:191-2 (1945) 1945

211 Sjövall H. Hormone Excretion in Chronic Polyarthritis. The Relation Between Sexual Function and Articular Disease in Women. *Scandinav* 117:69-89 1944

212 Ensign D C. Oral Focal Infection. *Statu Totus* 1:103-5 3:89-101 (April) 1945

tures are worn. Often fragment of roots are still present. Pulpless teeth should be watched. Teeth which show a radiolucent area may show infection. When extractions are performed sulfonamide drugs should be given before and at least twenty-four hours after extraction.

[ED NOTE—Rheumatoid arthritis remains a disease of uncertain cause. One is left with the necessity of considering all functional deviations of etiologic importance and of regarding their correction to be of possible therapeutic value.]

Meyer²¹³ states that all oral infection tends to spread into the venous system especially the jugular vein. After complete removal of oral infections the infection in the jugular veins disappears in some cases, but in most instances it persists as a latent focus of infection. He feels that this focus can play an important role in the production of rheumatic disease.

Mucoid hemolytic streptococci which are responsible in milk-borne epidemics of sore throat are found in less than 1 per cent of persons. Pilot²¹⁴ states that they are often found in the throat in rheumatic conditions. They are readily identified on brain-heart infusion blood agar plates. These organisms may disappear spontaneously or after the removal of the tonsils with relief of the arthritic symptoms.

TESTS

Steinberg and Lowenstein²¹⁵ observed the Weltmann reaction in 111 patients, 44 with rheumatoid arthritis, 27 with osteoarthritis and the remainder with other rheumatic diseases. Most patients suffering from arthritis showed a shift to the right above 7.5 in the Weltmann reaction. This test was of no value in the differential diagnosis of the various arthritic disorders. There was a definite relationship between the severity of the clinical symptoms and the degree of shift to the right of the Weltmann reaction. The reaction, in their opinion, is of definite prognostic value.

DIAGNOSIS

Fletcher and Lewis-Fanning made a statistical study of 1,000 cases of chronic arthritis.²¹⁶ There was more rheumatoid arthritis in women. Gout, fibrositis and scurica were commoner in men. The age distribution was the same in both sexes. Heavy laborers were prone to have

213 Meyer O. Mechanism of Oral Focal Infection. *M. Rec.* **158** 604-605 (Oct.) 1945.

214 Pilot I. Role of Mucoid Hemolytic Streptococci in Arthritis. *Proc. Central Soc. Clin. Research* **17** 70-71 1944.

215 Steinberg C. L. and Lowenstein F. W. Weltmann Reaction in Arthritis. *Am. J. Clin. Path.* **15** 395-401 (Sept.) 1945.

216 Fletcher E. and Lewis-Fanning E. Statistical Study of 1,000 Cases of Chronic Rheumatism. *Post Grad. M. J.* **21** 137 (April) 176 (May) 1945.

osteoarthritis develop. Clerks showed an excess of spondylitis. Obesity and hypertension were common in osteoarthritis. A blood sedimentation rate over 50 mm per hour was usually found in active arthritis.

The present classification of arthritis is unwieldy. Wilson²¹⁷ and that 95 per cent of all cases fit into the following classification: (1) rheumatoid arthritis, chiefly synovitis, (2) osteoarthritis, chiefly degeneration of the cartilage, (3) traumatic arthritis with or without degeneration of the cartilage, (4) specific infectious arthritis, often synovitis, (5) acute rheumatic fever, probably an allergic response in articular tissue, and (6) gouty arthritis.

Chronic monarticular arthritis is often²¹⁸ difficult to diagnose. Diagnosis sometimes can be made only by watching the course of the disease. Fourteen cases with monarticular symptoms six months or longer were followed for periods varying from two to fifteen years. Only 2 of the 14 proved to be cases of rheumatoid arthritis. Chronic monarticular arthritis is found in less than 0.5 per cent of the cases seen in an arthritic clinic. Surgical procedures or any treatment which may prove harmful should be avoided until a diagnosis can be made. Pain, however, should be relieved, deformity should be prevented and the joint should be protected while a diagnosis is being made.

Ropes and Bauer²¹⁹ state that in rheumatoid arthritis, as in all chronic disease, there are varied manifestations. Many nonarticular structures are involved. Usually there are prodromal symptoms, with an insidious onset and a slowly progressive course. It may resemble an acute infection at the beginning. Illustrative cases are reported of rheumatic fever, traumatic arthritis with articular derangement, ruptured intervertebral disk, psychoneurosis, fibrositis and intermittent hydrarthrosis in which diagnosis could not be made immediately.

The first act in chronic arthritis is to establish a diagnosis. One should not depend too much on the sedimentation rate and the roentgenogram. Improvement is usually not continuous. The patient must be treated as well as the joint. The affected joints should not be used too much. One must not expect too much from physical therapy. Gold salts must be given cautiously. In many instances the patient need not give up his job.

217 Wilson, C. P. Arthritis. A Workable Classification. *New England J. Med.* 44: 7-9 (Jan.) 1945.

218 Kuhn, J. G. Chronic Monarticular Arthritis. *New England J. Med.* 232: 128-132 (Feb. 1) 1945.

219 Ropes, M. W. and Bauer, W. Varied Clinical Manifestations of Rheumatoid Arthritis. *New England J. Med.* 233: 592 (Nov. 15) 1945.

220 Comroe, B. I. Common Mistakes in the Handling of Patients with Arthritis and Allied Conditions. *I. A. M. A.* 127: 392-395 (Feb. 17) 1945.

[ED NOTE—As more conditions are discovered which at times present articular inflammation, the diagnosis of rheumatoid arthritis is made with greater caution. Diagnosis is usually made by observing the course of the disease. Laboratory tests are merely confirmatory.]

REITER'S SYNDROME

Reiter's syndrome, described by Reiter in 1916, with the triad of arthritis, conjunctivitis and urethritis, was observed frequently in the armed forces, and, as one would expect, it was frequently confused temporarily with acute gonorrheal infections. It has not yet found its place in the classification of arthritis.

Twenty-five cases of this disease are reported from the Ashburn General Hospital.²²¹ Eleven of the patients had arthritis, conjunctivitis and urethritis, and 14 failed to have conjunctivitis. There was an explosive onset in all cases. Aspiration of joints was carried out in 8. Changes in the roentgenograms, chiefly osteoporosis, were found in 18, periosteal proliferation was seen in 3. The acute stage usually lasted four to six weeks. Most of the patients became asymptomatic in three months but a few continued to have symptoms after eight months. An arthrotomy in 1 patient in the eighth month showed intense inflammation in the synovial membrane but no change in the cartilage. It seemed to be a self-limited disease without residual damage. Rosenblum²²² states that the conjunctivitis and urethritis are transient (weeks), while the arthritis lasts longer (two to three months). Sulfonamide drugs and penicillin have no effect. The symptoms may recur. Roentgenograms are non-contributory, and laboratory studies show nothing except a mild leukocytosis.

The histories of the cases of 2 young men with Reiter's disease are given by Miller and McIntyre²²³ with a review of the literature. They state that rest is the only therapy. Administration of penicillin is useless. Full recovery occurs.

Colby²²⁴ studied a 21 year old student with this syndrome. No organisms were found. Sulfanilamide was given, with questionable benefit. There was no remaining disability. A second patient, a 26 year old workman, had hematuria. The urine was sterile but the right

221 Hollander, J. L., Fogarty, C. W., Jr., Abrams, N. R. and Kidd, D. M. Arthritis Resembling Reiter's Syndrome. Twenty Five Cases. *J. A. M. A.* **129** 593-595 (Oct. 27) 1945.

222 Rosenblum, H. H. So Called Reiter's Disease. Triad of Acute Arthritis, Conjunctivitis and Urethritis. *U. S. Nav. M. Bull.* **44** 375-378 (Feb.) 1945.

223 Miller, C. D. and McIntyre, D. W. Reiter's Disease. Urethritis, Conjunctivitis and Arthritis. *Ann. Int. Med.* **23** 673-682 (Oct.) 1945.

224 Colby, F. H. Renal Complications in Reiter's Disease. *Tr. Am. A. Genito-Urin. Surgeons* (1944) **37** 93-98 1945.

kidney, which was hydronephrotic, was removed. The hematuria disappeared, but the patient had recurrent attacks four years later. A third patient, a 26 year old physician, had sterile urine, but hematuria improved with dilatation of both renal pelvis. The author felt that renal pathologic changes should always be looked for in this disease.

Improvement in Reiter's disease followed the injection of 10 cc of boiled milk in a 38 year old man²²⁵. The arthritis improved following this induced pyrexia but still persisted. The other symptoms disappeared. This therapy was repeated in six days with the injection of 6 cc of boiled milk. After this all symptoms disappeared. The patient was still free from symptoms eight months later.

GOUT

Ficarra and Adams²²⁶ found that endogenous uric acid from a breakdown of nuclear material could cause a rise in blood uric acid content. Five patients were reported with postoperative gouty arthritis. All these patients were over 55 years of age and had osteoarthritis. The symptom of gout appeared within five days after operation. The great toe was usually involved. Hypoproteinemia was present in 4, and hyperuricemia was present in all. Hyperproteinemia stimulates endogenous purine metabolism. This complication can best be avoided by administration of adequate amounts of protein postoperatively.

Of 168 cases of polycythemia vera, the conditions in 8 were complicated by gout²²⁷. This condition may occur from the breakdown of cells which are the endogenous precursors of uric acid. This breakdown of cells may make mild gout severe or can make a case of severe gout difficult to control.

Hertzberg²²⁸ finds that alkaptonuria with ochronosis produces lesions in bone similar to osteoarthritis. The pigment is deposited in cartilage, and this is followed by friability of the cartilage. The articular capsule becomes thickened and small fragments of cartilage are buried in it. The history of a case is reported of a 54 year old fisherman with ochronosis and lesions in the left shoulder and both knees. An arthrotomy of the left knee was performed. Pigment was found in the synovial membrane and in the articular cartilage.

225 Strachstein A. Reiter's Disease. Case Successfully Treated. *New York State J Med* 45:2190-2191 (Oct 15) 1945.

226 Ficarra B J and Adams R. Postoperative Gouty Arthritis. *Arch Surg* 50:229-232 (May) 1945.

227 Tinney, W S, Polley, H F, Hall, B E, and Giffin, H Z. Polycythemia Vera and Gout. *Proc Staff Meet, Mayo Clin* 20:49-55 (Feb 21) 1945.

228 Hertzberg, I. Osteoarthritis Alkaptonurica (Ochronotica), *Acta radiol* 26:484-490 1945.

Neligan,²²⁹ in discussing the management of osteoarthritis, states that the cooperation of the patient is vital. The involved joints should be spared. All mechanical, metabolic and endocrine disturbances should be corrected. Work should be carried out for short periods at a time. The job should be fitted to the person. Reduction in weight may be necessary. Function, however, should be maintained. There should be active stretching and active training of special muscles. Physical therapy consists of local heat, diathermy, pool treatment, massage and exercises. Persistent pain in the joint usually is not due to osteoarthritis. In severe osteoarthritis operative fixation of the joint may be required. Occasionally salicylates, iodine and thyroid are helpful.

In conclusion he gives a five point program: 1. Secure the cooperation of the patient. 2. Insure the best possible environment. 3. Remove any recognized etiologic factors. 4. Maintain function as much as possible. 5. Relieve pain.

Hendry²³⁰ considers osteoarthritis to be an orthopedic problem chiefly. The helpful general measures are elimination of focal sepsis, correction of chronic constipation and reduction of obesity. As preventive measures he lists the teaching of proper weight bearing and posture (the correction of upset joint axes) and improvement of muscular weakness. Joints with a minimal amount of change may be manipulated preferably by repeated small manipulations. Rest and external fixation, either complete or by a spica, are useful temporary measures. A raised heel is sometimes required. Debridement of the joint, arthrodesis and arthroplasty have little place in the treatment of osteoarthritis. Osteotomy is at times of value.

[ED. NOTE.—The author does not give the indications for the various measures recommended.]

In a symposium on the treatment of unilateral osteoarthritis of the hip, Girdlestone²³¹ advocates surgical therapy when there is severe crippling. The operation should be adapted to the patient to provide the most useful hip. One has to consider pseudarthrosis, arthrodesis, arthroplasty, osteotomy and reconstruction in planning the treatment. Watson-Jones felt that arthrodesis of the hip with a flanged nail was the most effective therapy. Simple removal of articular cartilage usually led to failure. He reported that one hundred and thirty-five arthrodeses had been performed for osteoarthritis. Arthroplasty was advocated only in

229 Neligan, A. R. Management of Osteoarthritis. *Proc. Roy. Soc. Med.* **38**: 208-210 (March) 1945.

230 Hendry, A. M. Osteoarthritis as an Orthopedic Problem. *Practitioner* **155**: 89-94 (Aug.) 1945.

231 Girdlestone, G. R., Watson-Jones, R., Stamm, T. T., and Pringle, K. H. Discussion on the Treatment of Unilateral Osteoarthritis of the Hip Joint. *Proc. Roy. Soc. Med.* **38**: 363-368 (May) 1945.

severe bilateral osteoarthritis Stamm stated that arthroplasty found its chief usefulness in bilateral osteoarthritis. A metallic cup could be used, or a simple new joint could be designed. Pridie reported that he had performed one hundred and twenty-one operations (no statistics given). He found the cause of pain to be most often a shallow hip or aseptic necrosis of the femoral head.

RHEUMATOID ARTHRITIS OF THE SPINE

Mennell,²³² in discussing ankylosing spondylitis, states that it usually first appeared in three distinct age periods: in adolescents of 17 to 21 years, in young adults of 25 to 30 years and occasionally in older group. Early roentgenograms will show sacroilitis. Roentgen ray therapy offers the only prospect of improvement. This can be given as wide field or as local therapy. He feels that a plaster jacket is harmful.

Early diagnosis is made with difficulty in the prespondylitic phase, when only vague pains are present, according to Dekkers.²³³ Later there is sacroilitis with constant pain, followed by the poker back deformity. Diagnosis is often made only three to six years after the onset. The peripheral and the spinal joints should be considered as one morbid entity. Spondylitis usually does not react well to gold treatment. McWhirter²³⁴ states that little or nothing can be done when the disease is far advanced. In his group it usually first appeared in the third decade. Ninety-one per cent were males in a group of 162. It was often treated at first for fibrositis or lumbago. Biopsy specimens to determine the stage of the disease process were readily obtained at the articulation between the manubrium and the body of the sternum. The lesions in the spine suggest a similar distribution to those seen in metastases from carcinoma of the prostate. The first treatment should be roentgen ray treatment up to 2,500 r units. He advises desoxycorticosterone acetate and increased salt content in the diet for roentgen ray sickness. Roentgen ray treatment alone is not adequate. In early cases there should also be physical therapy with deep breathing exercises. A brace is used when the patient gets up. In more advanced conditions a light plaster jacket is used for six to twelve months. In advanced cases a jacket is worn for support indefinitely.

[ED. NOTE.—In this problem of support to the spine one should be guided by the clinical indications. If there is acute pain on any motion

232 Mennell, J. M. Ankylosing Spondylitis, *M. Press* 212 378-380 (Dec. 19) 1944

233 Dekkers, H. J. N. Spondylarthritis Ankylopoetica (Spondylitis Rheumatica) Combined with Peripheral Arthritis, *Acta med. Scandinav.* 113 265 1943

234 McWhirter, R. Ankylosing Spondylitis, *Brit. J. Radiol.* 18 12 (Oct.) 1945

a rigid support which immobilizes the spine is required. Later, when pain subsides, support should be used only to prevent deformity. All support should be discarded when there is no further tendency to forward bowing. Many patients, however, are never comfortable without spinal support.]

A relationship between changes in the cervical spinal articulations and the Barre-Lieou syndrome is postulated by Jonsson²³⁵. Headache, faintness and varying symptoms in the eyes and ears were found, usually associated with changes in the cervical vertebrae, particularly in the vertebral joints. One patient with this syndrome died, and the cervical portion of the spine showed no compression of the vertebral canal. He states the belief that these symptoms originate in the sympathetic nerves.

In 2 cases of advanced spondylarthritis, pieces of thyrotoxic goiter were implanted in the posterior rectus sheath. This was followed by improvement. The author²³⁶ expresses the opinion that there was no direct relationship but that the improvement came from the increased basal metabolism. In 2 cases of less severe conditions, thyroxin was given and improvement resulted.

Wyatt²³⁷ advocates twenty treatments of 33 r units plus exercises for ankylosing spondylitis. The sedimentation rate is raised at first when treatment is given, but it goes down later. Improvement usually follows this treatment. One hundred and sixty patients with arthritis of the spine at Duke University²³⁸ were given roentgen ray treatment. One hundred and twenty-three were between 20 to 39 years of age, 40 of these patients were seen with the condition in an early stage, in 58 it was moderately advanced and in 38 it was far advanced. With a combination of orthopedic treatment and roentgen ray treatment 76 per cent improved. Women must be treated with caution and with smaller dosage. Vomiting following roentgen ray therapy can be helped by giving tablets of vitamin B₆. Repeated series of roentgen rays are given if the sedimentation rate is increased and symptoms become worse. Twenty per cent of 99 patients reported in a follow-up letter that they were free of symptoms one year after roentgen ray treatment. The best results are obtained when roentgen ray treatment is given early.

235 Jonsson E. Changes in the Uncovertebral Joints of the Cervical Spine in Relation to Barre-Lieou Syndrome. *Acta chir. Scandinav.* **87** 154-168 (1942)

236 Mandl F. Attempts to Influence Spondylarthritis Ankyloptica by Means of Implantation of Toxic Goitre. *J. Internat. Coll. Surgeons* **6** 529-536 (Nov.-Dec.) 1943

237 Wyatt H. Ankylosing Spondylitis. *Brit. J. Radiol.* **18** 201-202 (Oct.) 1945

238 Hemphill I. E. and Reeves R. I. Roentgen Irradiation in the Treatment of Marie-Strümpell Disease (Ankylosing Spondylarthritis). Analysis of One Hundred and Sixty Cases. *Am. J. Roentgenol.* **54** 282-289 (Sep.) 1945

SURGICAL TREATMENT

Batchelor²³⁹ advocates excision of the femoral head and neck in the presence of ankylosis of the hip in arthritis. This leads to potential instability. Calipers must often be used for months. A subsequent Schanz osteotomy was required in 2 cases. Both procedures can be carried out at the same time by the use of a bent plate. These procedures relieve pain and permit motion.

Karlen²⁴⁰ had performed sixteen arthroplasties for osteoarthritis of the hip by 1943. Of these, seven were carried out with fascial transplants, and a vitallium cup was used in nine. The results of two of the fascial arthroplasties were good, and the results of three were good with vitallium cups. Three fascial arthroplasties gave fair results. Results of two fascial arthroplasties were poor and six vitallium cup arthroplasties gave poor results. One vitallium cup arthroplasty was too recent for report. The author felt that the chances of a good result following arthroplasty in arthritis deformans were slight. Good results were not achieved after patients were 30 years. Such operations were not for persons who had to follow a strenuous occupation.

The late results of arthroplasty for ankylosis of the hip are reviewed by Langenskiöld²⁴¹. Most such attempts at forming a new joint should more properly be called arthrolysis. Of 15 cases, the reasons for operation were bilateral ankylosis in 3, ankylosis in faulty position in 11 and inability to carry out coitus in 1. The articular surfaces were reshaped and fascia was interposed. The criteria of Campbell were used in studying the end results. In 3 they were excellent, with motion between 50 degrees and 160 degrees, in 3 they were good and in 1 they were doubtful. The author could not prognosticate from the nature of the lesion whether ankylosis would recur. Ankylosis recurred in 8 cases. In 1 case total destruction of the head and neck occurred on both sides ten years after arthroplasty for gonorrheal arthritis. The operation has been recommended with caution since 1926.

[ED NOTE—The editor has noticed during the past five years that many of these newly formed joints wear out with great rapidity. It may be that the bone in chronic arthritis is less resistant to continued use. Even in non-weight-bearing joints, subluxation or persistent pain and stiffness are common occurrences after five to ten years of use.]

239 Batchelor J S. Excision of the Femoral Head and Neck in Cases of Ankylosis of the Hip. *Proc Roy Soc Med* 38 689-690 (Oct) 1945.

240 Karlen, A. Arthroplasty in Arthritis Deformans, *Acta med Scandinavica* 90 482-494 1944.

241 Langenskiöld F. Late Results of Arthroplasty in Ankylosis of the Hip. *Acta chir Scandinavica* 91 254-268 1944.

Smith-Petersen and his associates describe a procedure for partial correction of flexion deformity of the spine²⁴² in ankylosing spondylitis. The bony ankylosis between the laminae and between the articular facets is freed with a chisel. Histories of 6 cases are reported showing some correction of the flexion deformity.

Arthroplasty of the first metatarsophalangeal joint is described by Crosby and Galasinski²⁴³. After the ends of the bones were reshaped, tantalum 0.015 inch (0.03 cm) thick was shaped over a mold and this was later sterilized and fitted over the metatarsal head. Active motion and freedom from pain were observed six months later.

THErapy WITH GOLD COMPOUNDS

Block and Knapp²⁴⁴ studied the in vitro effect of various gold compounds on the oxygen consumption of fresh slices of liver and kidney from healthy white rats. They found that the oxygen consumption was inhibited by inorganic ionizable compounds of gold: gold chloride and gold sodium thiosulfate. There was less inhibition by colloidal gold sulfide. Organic nonionizable compounds: sodium succinimidoaurate, gold sodium thiomalate and gold thioglucose did not cause any inhibition. Those compounds which did not have any effect on the oxygen consumption of tissue slices are the compounds which produce the least toxic effects.

In gold therapy one is treating a disease of unknown causation with a medium whose dosage and mode of action are obscure and whose toxic potentiality is unpredictable²⁴⁵. Cutaneous rashes are the commonest toxic reactions. Gold therapy is indicated only in rheumatoid arthritis in which there is an 80 per cent chance of improvement and a 0.5 per cent chance of dying from the drug.

Cohen and colleagues²⁴⁶ review 259 patients who were treated with gold (aurothioglucose in oil). Objective improvement was observed in 88 per cent of these patients. There was one fatality from thrombo-

242 Smith-Petersen M N, Larson C B and Aufranc O F. Osteotomy for Correction of Flexion Deformity in Rheumatoid Arthritis of the Spine. *J Bone & Joint Surg* **27** 1-11 (Jan) 1945.

243 Crosby E H and Galasinski R E. New Arthroplasty for Small Joint. *Connecticut M J* **9** 926-928 (Dec) 1945.

244 Block W D and Knapp E I. Metabolism, Toxicity and Manner of Action of Gold Compounds in the Treatment of Arthritis. Effect of Various Gold Compounds on Oxygen Consumption of Rat Tissues. *J Pharmacol & Exper Therap* **83** 275-278 (April) 1945.

245 Lansbury I. Gold Therapy in Arthritis. *Pennsylvania M J* **47** 217-220 (Dec) 1943.

246 Cohen A, Goldman I and Dubbs A W. Treatment of Rheumatoid Arthritis with 417 Compounds of Gold. Analysis of 259 Cases. *New England J Med* **233** 199-203 (Aug 11) 1945.

cytopenic purpura. They found that 300 mg of vitamin C daily or vitamin B complex daily did not lessen the number of toxic reactions. A normal sedimentation rate was no contraindication. Toxic reactions occurred in 10.3 per cent. Toxic reactions were more frequent in those receiving two or more courses of gold.

Comroe²⁴⁷ states the belief that gold therapy is of value only in rheumatoid arthritis. It is not a specific therapy. Toxic reactions may appear at any time. Ten to 20 per cent of the patients relapse after gold treatment. While this treatment is often helpful, it must be given with caution. It should be used only after the usual conservative treatment fails. Gold is the only drug which shows promise of checking the disease. Its mode of action is unknown. The gold is excreted slowly. Much remains in tissues a long time. Colloidal gold usually shows neither toxic nor therapeutic benefits. The dosage in the usual course is 850 mg of gold. It may be repeated in eight weeks.

A new gold preparation, Lauron (aurothioglycolanilide), containing 54 per cent gold, is given by intramuscular injection.²⁴⁸ It is less toxic than the usual compounds used. Twenty-five to 300 mg can be given. Fifty-five patients have been treated, but no results can be reported yet. Stengel²⁴⁹ reports on 30 patients treated ten months or less with aurothioglycolanilide. The toxicity seems to be dependent on the radical to which the gold is attached. All the patients (rheumatoid arthritis) showed some improvement. The improvement was shown by less swelling in the joints in four to five weeks. In 4 patients conjunctivitis developed.

OTHER METHODS OF TREATMENT

Roentgen therapy was advocated as a local treatment only by Borak and Taylor.²⁵⁰ Kaplan²⁵¹ treated 141 patients with arthritis with roentgen rays (no statistics are given), 100 to 200 r are given once or twice a week until the patient becomes comfortable. He expresses the opinion that the results are lasting. No harmful effects were observed.

Radon, the first product of disintegration of radium, was used to treat arthritis by Lustig.²⁵² Thirty-five patients were treated with radon.

247 Comroe, B. I. Abuse of Gold Therapy in Rheumatoid Arthritis. *J. A. M. A.* **128**: 848-851 (Jul. 21) 1945.

248 Robinson, D. New Gold Preparation (Aurothioglycolanilide), *Canad. W. A. J.* **53**: 279-280 (Sept.) 1945.

249 Stengel, E. New Gold Compound (Aurothioglycolanilide). *Bull. H. Joint Dis.* **5**: 114-121 (Oct.) 1944.

250 Borak, J., and Taylor, H. K. Beneficial Effects of Roentgen Therapy in Advanced Cases of Rheumatoid Arthritis, *Radiology* **45**: 377-384 (Oct.) 1944.

251 Kaplan, I. I. Roentgen Therapy of Arthritides, *New York State J. Med.* **45**: 1339-1343 (June 15) 1945.

252 Lustig, F. Radon and Physical Therapy in Arthritis, *M. Rec.* **155**: 225-228 (April) 1945.

ointment which contained 200 electrostatic units per cubic centimeter Six treatments of 12,000 electrostatic units each were given A certain amount of improvement was reported

Danowski and colleagues²⁵³ report 2 cases of renal damage secondary to prolonged treatment with large doses of vitamin D One patient a 47 year old housewife, took 150 000 to 200,000 units of vitamin D daily between 1936 and 1942 There was a fluctuant swelling on the left wrist and ankle containing chalky material Albumin gradually disappeared from the urine, and blood calcium and phosphorus levels became normal Later the chalky deposits disappeared The second patient was a 56 year old woman who received 500 000 units of vitamin D for five months There were hypertension and hypercalcemia and a urine of constant low specific gravity There was poor excretion of phenolsulfonphthalein They feel that administration of large doses of vitamin D demands careful supervision

The effect of jaundice on arthritis was reviewed by Gardner and his associates²⁵⁴ Thirty-two patients with rheumatoid arthritis were inoculated with the virus of infectious jaundice In 10 cases the conditions were mild, in 5 moderate, in 11 severe and in 6 extremely severe Jaundice appeared after inoculation in twenty-seven to one hundred and thirty-one days No change was observed during the incubation period Remissions which followed the appearance of jaundice were variable and of short duration, 15 patients were completely free from pain and swelling, and 15 others showed improvement The average period of improvement was forty-two days There was no definite relationship between the intensity of the jaundice and the type of remission which was produced The authors did not advocate this as a therapeutic measure and felt that it was justifiable only as a research project

Penicillin injected intramuscularly in 7 cases of hydrarthrosis was demonstrated in the synovial fluid The concentration of penicillin both in the blood serum and in the fluid in the joints was determined by the cup assay method²⁵⁵ The penicillin penetrated into the joint readily and left the articular cavity more slowly than the blood serum A sufficient amount entered the joints with the usual dosage 25 000 to 40,000 units every three hours, and attained levels in the articular cavity comparable to those in the blood serum

253 Danowski T S Winkler, A W, and Peters, J P Tissue Calcification and Renal Failure Produced by Massive Dose Vitamin D Therap *Ann Int Med* 23 22-29 (July) 1945

254 Gardner, F Stewart, A, and MacCallum F O Therapeutic Effect of Induced Jaundice upon Rheumatoid Arthritis *Brit M J* 2 677-689 (Nov 17) 1945

255 Balboni V G, Shapiro, I M, and Kadd D M Penetration of Penicillin into Joint Fluid Following Intramuscular Administration *Ann J M Sc* 210 588-591 (Nov) 1945

GENERAL THERAPY

In a lecture on atrophic arthritis before the Glasgow Medical Society Davidson^{25,6} reviewed the various etiologic factors which have been suggested and gave an outline of treatment. Data were gathered from 388 patients. A diagnosis of rheumatoid arthritis was made by the presence of persistent periarticular swelling, involvement of wrist metacarpophalangeal or interphalangeal joints, the presence of muscular wasting, absence of specific causation of the arthritis and roentgenologic evidence compatible with rheumatoid arthritis. In regard to heredity he found no proof of a predisposition to arthritis. There was no special body build. He expressed the opinion that the reduced incidence in the tropics was probably related to diet, housing temperature and infection. Environmental conditions increased the chance of cross infection and reduced the patient's resistance. There was no proof of any direct relationship to pregnancy.

The menopause did not tend to precipitate the onset of rheumatoid arthritis. No proof was obtained that a failure of absorption, utilization or excretion of any dietary factor was of primary etiologic importance. While an adequate ingestion of vitamins was advisable in any chronic disease, no proof was shown that vitamin deficiency led to arthritis. Disorders of the endocrine glands played no specific role but the peripheral circulation and the permeability of the capillaries could be altered by the products of certain glands. While there were many features which favored the view that infection played some etiologic role there was no proof that it was an infectious disease. Infection had occurred within two months of the onset of arthritis in 12 per cent of the men and 21 per cent of the women. Focal sepsis was present in 38 per cent. The allergic hypothesis was accepted as a working basis for prophylaxis and treatment. This was supported by a great deal of experimental work in animals, and it gives an explanation of certain clinical findings.

Treatment should be of the whole patient in an attempt to raise resistance. In regard to the general health fatigue should be eliminated, pain reduced and psychologic factors removed. Special postural and breathing exercises should be given. Focal sepsis should be removed with sulfonamide drugs given at the same time. Attempts at desensitization should be reconsidered. The entire question of vaccine should be reviewed. Gold salts might be tried in small doses. Proper care should be given to the affected joints. Drugs should be used only as they are indicated.

256 Davidson L. S. P. Etiology and Treatment of Rheumatoid Arthritis. *Trans. Roy. Med.-Chir. Soc. Glasgow* 1943-1944 pp. 2-5 and 6-16. in *Glasgow Med. J.* December 1943 and January 1944.

Roland²⁵⁷ states that the Veterans Administration cannot care for all patients with arthritis in hospitals. Many must be cared for at home. Home treatment should include psychotherapy, occupational therapy and physical therapy. Mental changes take place in a chronically ill patient—depression and fear—so that the therapy is inadequate. Occupational therapy keeps the mind occupied and gains confidence. Graded activity and physical therapy are given to stimulate circulation, to prevent contractures and muscular wasting and to correct deformities.

Kovacs²⁵⁸ discusses the uses and limitations of physical therapy in chronic arthritis. It is the oldest standby in therapeutics. Heat locally increases the circulation and tissue metabolism, relaxes spasm and relieves pain. The bath in liquid petrolatum is a useful local form. Short wave diathermy should be measured in dosage. Diathermy about the area of a focus of infection may increase the sedimentation rate temporarily. Artificial fever therapy is disappointing. There is only occasional improvement. Thermal effect with friction is particularly useful for the feet. Exercises under water are equally effective and can be used at home. Counterirritation, galvanic current and ionization are helpful for a time. If the physical therapy at home is supervised intelligently, it can be of great help.

MISCELLANEOUS

Hickam²⁵⁹ gives the articular manifestations of lymphogranuloma venereum as arthralgia, acute polyarthritis, chronic recurrent polyarthritis, tenosynovitis and bursitis. Histories of 4 cases are reported in detail. He advises the use of a dilution of chick antigen in patients with active disease.

Arthralgia and myalgia are common at the onset of fever in meningococcic infections, but this is of little consequence.²⁶⁰ Purulent arthritis occurs occasionally but is rare since sulfonamide compounds have been used. Histories of 2 cases of severe purulent polyarthritis are given. Operation is not indicated. The arthritis begins as an acute synovitis. Restoration of articular function commonly occurs.

Arthritis produced by the injection of silver nitrate into the tibio-tarsal joints of rats was used to test synaptic transmissions in the soleus and tibialis anterior muscles.²⁶¹ The third stage of neuromuscular trans-

257 Roland P. E. Home Treatment Program for Chronic Arthritis. *Occup Therapy* **24** 160-162 (Aug) 1945

258 Kovacs R. Newer Methods of Physical Therapy in Chronic Arthritis. *Tr Am Therap Soc* **42** 24-29 1942

259 Hickam I. B. Cutaneous and Articular Manifestations in Lymphogranuloma Venereum. *Arch Dermat & Syph* **51** 330-336 (May) 1945

260 Boger W. P. Purulent Meningococcal Arthritis. *Am J M Sc* **205** 708-717 (Dec) 1944

261 Frugone I. E. Thomsen P. and Lucco J. V. Synaptic Transmission of Muscles in Arthritis. *Proc Soc Exper Biol & Med* **59** 226-229 (June) 1945

mission was different in arthritis. The atrophic muscles were also more resistant to curare. Neostigmine methylsulfate produced more depression and less potentiation in arthritic muscles. The synaptic behavior of arthritic muscle was similar to the behavior of tenotomized, immobilized and fatigued muscles.

Lovgren²⁶² studied 99 cases of chronic polyarthritis and found decreased cevitic acid and serum iron in rheumatoid arthritis. In osteoarthritis there was an increased cevitic acid, which was found greatly increased in allergic arthritis. Under treatment the value returned to normal. A fatty liver was found in 42 per cent, amyloid of the liver in 8 per cent and cirrhosis in 10.7 per cent. Adenylphosphoric acid was used in dosage of 30 to 45 mg daily intravenously and intramuscularly in 144 patients. Of these 95 improved.

Tabetic arthropathies may change greatly in two months.²⁶³ The destruction of the afferent nerves renders the joints incapable of compensating for injury. Charcot's joint is found in 4 to 10 per cent of tabes and in 25 per cent of syringomyelia. The early treatment is support and rest until acute symptoms pass. Fusion of the joints is no longer advocated. A corset is used for the spine. In the hip walking with two crutches or a low subtrochanteric osteotomy is advised. A caliper with knee pad is best for the knee. This is later changed to a lock joint with an elastic support for the knee and a cane. An ankle brace and foot pads are used for the ankle and foot. Pressure must be avoided, or trophic ulcers may result. Fractures heal as in normal bones. Amputation is rarely necessary.

Frankel and his associates²⁶⁴ produced *Staphylococcus aureus* infection in the knee joints of rabbits, twenty-four to forty-eight hours later penicillin (amount not stated) and propamidine (4,4'-diaminodiphenyl oxypropane) 1 per cent were injected into the knee. In all animals sterile joints developed with little or no damage. Propamidine was highly toxic for all the animals.

262 Lovgren O. Intermediary Metabolism in Chronic Polyarthritis. Therapeutic Deductions with Special Consideration of Adenylphosphoric Acid. *Acta Med Scandinav*, 1945, supp 163, pp 1-150.

263 Kev, J A. Treatment of Tabetic Arthropathies. *Urol & Cutan Rev* 49 161-166 (March) 1945.

264 Frankel C J, Lee R W and Houlahan R B. Experimental Infection with Penicillin and Propamidine in Acute Purulent Arthritis, *Exper Med & Biol* 2 290-297 (Nov) 1944.

ARCHIVES OF SURGERY

VOLUME 54

APRIL 1947

NUMBER 4

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NEWER METHODS OF ABDOMINAL DRAINAGE

W WAYNE BABCOCK M D

PHILADELPHIA

ABDOMINAL drains have been used since the early days of abdominal surgery. Then the surgeon, fearing to leave ligatures within the abdominal cavity, left the ends hanging from the wound, that he might tug at them from time to time until they loosened and came away. Again an exigency compelled the surgeon to leave the wound open, as in one of the early hysterectomies (W Burnham 1853), in which the patient strained as the abdomen was opened and extruded the fibroid tumor. Being unable to replace it within the abdomen, the operator left the wound open, as did Koeberle in later years with the cervical stump after hysterectomy. The need of continued evacuation of septic or contaminating accumulations was early recognized and finally Keath placed long glass tubes (Keath's drains) to the depths of the abdomen, which were aspirated by long-nozzled hard rubber syringes at regular intervals, a procedure that passed out of use about fifty years ago.

During the last war, becoming interested in the local reaction from waxed sutures and ligatures which had been popular with a previous generation of surgeons, I began an investigation which later included the reactions of the tissue to other foreign substances used as drains. Phases of the subject later were assigned to my surgical residents: Dr Gerald Pratt¹, Dr Daniel Preston² and Dr O P Large³ during their three year terms of service.

In the dog's abdomen it was found that catgut sutures exposed on the peritoneal surface in closing an incision in the stomach were soon covered by dense adhesions. Over silk or cotton sutures there were adhesions but of lesser degree, while over stainless steel wire sutures no adhesions had formed at the end of two weeks. This showed the fallacy of trying to prevent peritoneal adhesions by peritonealizing denuded areas with catgut sutures. The catgut might even produce adhesions denser than those

From the Surgical Department of Temple University School of Medicine.

1 Pratt G. Steel Wire as a Suture Material. *Surg Gynec & Obst* 74:845 1942.

2 Preston D I. Effects of Suture on Strength of Healing Wounds. *Am J Surg* 49:56 1940.

3 Large O P. Comparison of Suture Reaction. *Am J Surg* 40:415 1945.

that would form over an open denudation.⁴ A result was the substitution of fine stainless steel sutures on peritoneal surfaces for those of catgut wherever they seemed practicable. Applying these observations to abdominal drains it was evident that in some cases it was desirable to produce early adhesions to localize the drained area, while in others adhesions would prevent the drainage of outlying septic areas and be harmful. It was known that gauze drains were isolated by the formation of adhesions in one half hour to two hours. Was it possible, by using a drain made of material to which the peritoneum did not react to drain much or all of the peritoneal cavity? This was then considered impossible by many surgeons. Like gauze a section of rubber tubing left in the dog's abdomen was found at the end of two weeks not only encased in dense adhesions but beginning to ulcerate into any adjacent hollow viscus. Trials with plastics (such as "bakelite," "lucite" and cellophane) produced marked fibroplastic reactions. Glass tubing and stainless steel tubing left in the abdomen for two weeks, on the contrary, produced no adhesions.

In human practice repeated observations likewise indicated that drains made of glass or stainless steel could remain in the abdomen for several days without the formation of adhesions even though they communicated with the outside air. Large open glass tubes (lamp chimney drain) anchored with stainless steel wire sutures over intestinal suture line as a protection against leakage or necrosis of the bowel showed no adhesions at the end of four days, and on their removal the adjoining intestinal coils floated over one another, free from adhesion. Similarly when the abdomen was opened for ileus several days after the insertion of a large glass drain, no adhesions were found about the glass.

Fatal bacteremia has followed the early removal of an adherent gauze drain from an extremely septic abdominal wound. Six such cases were reported in a single year from the Philadelphia General Hospital. In each removal lymph spaces are torn open, with entrance of bacteria into the circulation. The adherent area may be greatly reduced and the danger and pain of removal lessened by use of nonadherent drains or, when gauze is used, by bringing it from the depths of the wound through a narrow tube of glass or stainless steel. This arrangement also may be helpful when gauze packing is used to control hemorrhage, as from a lacerated liver. In such a case I have controlled a recurrent hemorrhage with-

4 Jenkins H P, Hrdina L S, Owens F M Jr and Smith F W. Absorption of Surgical Gut (Catgut). Duration in Tissues After Loss of Tensile Strength. *Arch Surg* 45:74 (July) 1942. Jenkins H P. Absorption of Surgical Gut (Catgut). Recommendations for Absorbability and Digestion Reactions. *ibid* 45:323 (Aug) 1942.

5 Jenkins M H. Alloy Steel Wire (Babcock) Suture. *Penn Med J* 41:707 1938.

reopening the abdomen by packing additional gauze through the tube with a gauze packer the gauze of course being used in a continuous strip

STAGE DRAINAGE

Stage drainage under the protection of quarantine adhesions may be accomplished by anchoring with fine stainless steel wire sutures a glass or other tube of large caliber (chimney drains) over the part to be drained. A light gauze packing within the tube will stimulate the formation of adhesions after the formation of which the septic collection may be evacuated through the tube without contaminating other parts of the peritoneal cavity. The mortality from simple cholecystostomy or cholecystectomy is high when used for extremely septic types of acute cholecystitis, but my colleagues and I have had no mortality in the 17 cases in which this method was used. It is important to anchor the tube with wire sutures which are tied over the upper edge of the tube, and to delay opening the gallbladder until after adhesions have formed or four to five days. To open the gallbladder a circular portion of the wall is removed through the chimney drain by galvanocautery or high frequency current. The glass tube is permitted to remain in place two or three days longer for the formation of stronger adhesions after which the stones and finally the retaining sutures are removed, and the tube withdrawn. The removal of the chimney drain and opening of the gallbladder during the first forty-eight hours after operation or before adhesions had formed, led to fatal peritonitis in 2 cases in which the operator did not understand the method.

The lamp chimney drain also may be used for the stage evacuation of a localized appendical or other intraperitoneal abscess without contamination of the general peritoneal cavity. The opening and drainage of an appendical abscess through the open peritoneal cavity had previously had a mortality of 6 per cent in my hands. With the drain anchored over an intestinal suture line the degree of healing may be observed day by day and necrosis and leakage detected by the color of the bowel or by the odor of the exudate tested with a sterile cotton swab. A similar drain except for a curve anchored by suture over the prostatic bed after a suprapubic prostatectomy and containing a small aspirating tube has been followed by a much smoother convalescence than any of the various other methods which we have tried.

SUMP DRAINS

For prolonged drainage of the general peritoneal cavity I have used since 1934 perforated tubes made of glass or stainless steel. In the tube

⁶ Babcock W. W. Wire Suture. *J. A. M. A.* **102** 1752 (May 26) 1934.
Drains. *Am. J. Surg.* **27** 67 1935. **36** 3 1957.

is placed a second aspirating tube which is connected by rubber tubing with a water spigot aspirator or an electric pump of low capacity. A $\frac{1}{60}$ horse power or 'flea power' motor with an intermediate collecting bottle is adequate if it is designed to run continuously for days without overheating or need of additional lubrication. A sump drain is of great advantage when there is intraperitoneal exudation, leakage or contamination, as in the following conditions:

Intraperitoneal Leakage from a Perforated Appendix with Diffuse Purulent Peritonitis.—A short transverse muscle-splitting incision is made, the appendix delivered, the base ligated, divided by cautery, and the divided mesoappendix ligated to the stump with the ends of the ligature. Without sponging or otherwise irritating the peritoneum, a perforated sump drain 6 to 10 mm. in diameter is inserted to the bottom of the pelvis and the surrounding wound is lightly closed with fine interrupted stainless wire sutures. Aspiration is then started and continued without interruption. Beginning with thick, odorous pus, the aspirated fluid soon turns to a thin odorless seropus and then to clear serum which gradually decreases to only 5 or 10 cc. a day, the drain is then withdrawn and the small opening permitted to close. By this plan the disability and period of hospitalization has been reduced, the patient being out of bed and the wound practically healed in twelve or fourteen days. Thus the operative time is shortened, painful dressings with liberation of adherent drains are eliminated and the incidence of secondary peritoneal abscess, troublesome adhesions and incisional hernia is reduced.

In rupture or perforation of the stomach or bowel, aspiration drainage is of great value. For example in a patient with an obstructive carcinoma of the transverse colon, who had continued to take solid food and also had been given barium by mouth and by enema for roentgen study, the greatly distended colon burst when exposed and elevated, instantly flooding the abdominal cavity with a great quantity of barium and other intestinal contents. The diseased portion of bowel was quickly exteriorized and two sump drains inserted into the upper part of the abdomen and a third through a suprapubic stab wound to the bottom of the pelvis. Although fecal particles were evacuated by the pelvic sump to the seventh day, signs of active peritonitis did not develop and the patient recovered from the operation to succumb several years later to metastatic growths in the liver.

In the last 11 consecutive complete gastrectomies I have used sump drains with but 1 fatality. In 3 patients the esophagoduodenal anastomosis leaked but spontaneous closure and a satisfactory operation

7 Babcock W. W. Improvements in Abdominal Drainage. Proc. P. S. A. 1938. VI. Assemb. North America 1938 p. 166.

8 Babcock W. W. Prevention and Control of Peritonitis. VI. Doctor 20 147 1942.

recovery then followed. In many of these patients additional cigaret drains to produce adhesions also are desirable.

Biliary Surgery—After cholecystectomy and operations on the bile ducts, sump drains have been used routinely during the past eight years and have demonstrated that after many cholecystectomies in which the cystic duct is doubly ligated, from 30 to 1 500 cc of bile and bloody serum leaks into the peritoneal cavity during the first three days after operation. The bile evidently escapes from accessory bile ducts usually on the denuded surface of the liver, and by its immediate evacuation the convalescence has been more rapid and uniform.

As the sump, properly used, is capable of taking care of any leakage of bile, in operations on the common duct we have discontinued the use of T or other intraductal rubber tube drains, closed the duct with extremely fine interrupted stainless steel wire sutures and placed the tip of the sump drain close to the suture line. Usually bile is then evacuated for the first two or three days after the operation. When this ceases the drain is removed. By this procedure a low mortality is obtained and the patients, instead of having draining tubes and sinuses for weeks after an operation on the common duct usually are healed and able to leave the hospital within ten days of the operation. Moreover, the irritation and secondary ascending infection of the ducts from indwelling rubber tubes are eliminated.

Resection of the Large Bowel for Carcinoma—After resection and primary end to end anastomosis of the large bowel, an adjacent sump drain is used routinely to keep the peritoneal cavity relatively dry of blood and serum, which may spread the infection. Should the edges of the bowel fail to unite and leakage occur the change in color and odor of aspirated fluid demonstrates the condition and usually a fistula forms along the drainage tract, which in most cases closes spontaneously. To stimulate the formation of adhesions about the anastomosis the suction drain of Chaffin, made of a loop of perforated rubber tubing may be used. Convenient for aseptic intestinal anastomosis are the Furniss and other modifications of the Donati clamp. The narrow edges of contiguous bowel shirred on the pin are convenient to sew over and facilitate the rotation of the bowel in suturing the opposite side. Combined with the use of sump drains the results have been so satisfactory that although we have performed radical operations for cancer of the large bowel in 97 per cent of the patients presenting themselves in the last three and one-half years, only one stage operations have been performed unless there was perforation.⁹

Carcinomas of the large bowel 11 cm. or more above the anal verge have been treated by excision and end to end aseptic anastomosis. Those from 5 to 10 cm. above the anus have been treated by wide trans-

⁹ Babcock, W. W. and Bacon, H. E. Carcinoma of the Rectum. One Stage Abdominoperineal Proctomigmoidectomy. *S. Clin. North America* 22: 1661, 1927.

abdominal liberation of the rectosigmoid followed by abdominal closure with a sump drain to the pelvic floor¹⁰. The rectum is then dissected and occluded by packing with gauze wet with tincture of iodine and a posterior midline incision is made through the sphincters and the pelvic floor to the coccyx. The rectum is divided and liberated above the sphincters and, with the sigmoid, pulled through the split anal ring. The pelvic floor is then reconstructed in layers with interrupted 32 stainless wire sutures and closed without tension about the withdrawn sigmoid, which is amputated 6 to 10 cm. beyond the anus after drains have been applied. This leaves the withdrawn bowel surrounded by the divided sphincters. A week later the redundant protruding bowel is removed by a snare or cautery and the short stump retracts forming a linear union with the upper edges of the anal mucosa just above the sphincters. As no perineal drains are used the linear midline scar is inconspicuous and the anus has a normal appearance and retains contractile power.

For the small percentage of carcinomas of the anus and adjacent part of the rectum a wide perineal resection is used with removal of enlarged inguinal lymph nodes. As an indication of the advantage of adequate drainage in a recent series of 100 consecutive cases of carcinoma of the large bowel all treated without abdominal colostomy there were only 2 patients with malignant disease too far advanced for radical operation, and of the remaining 98 patients after radical resection only 4 died in the hospital—1 of coronary occlusion and 3 who had advanced metastasis to the liver. In 615 radical operations for cancer of the large bowel, about 20 per cent of the patients had metastasis to the liver and others had invasion of bladder, small intestine, uterus or other part, yet with adequate drainage the mortality and morbidity from radical resection of the primary growth has become less than that from a Paul-Mikulicz operation. Many of the patients with carcinoma of the liver have lived two years or more after radical operation and 1 has lived over seven years.

With the use of sump drains the operative treatment of ulcerative and polypoid colitis also has changed. Instead of a primary ileostomy which is responsible for a mortality of 6 to 8 per cent a primary two-stage hemicolectomy with end to end anastomosis between ileum and colon is performed, followed at a second stage by removal of the diseased portion of the large bowel to the rectum and an ileoproctorrhaphy.

ELIMINATION OF COLOSTOMY

A large percentage of patients with a colostomy opening after the conventional Miles operation for carcinoma of the rectosigmoid are

10 Babcock W. W. Operative Treatment of Carcinoma of the Rectum. *Surg. Gynec. & Obst.* 55:627, 1932. Babcock and Pacon.

lymphopathy of the rectum ulcerative or polypoid colitis, diverticulitis of the sigmoid or rectal injury from heavy irradiation welcome the chance of having the colostomy transplanted to the perineum. With aspiration drainage this has a low mortality and even in the absence of sphincters patients find the perineal opening much more convenient than one in the abdomen. Measures similar to those used after abdominal colostomy are for the perineal opening, even more satisfactory to insure regulated complete evacuations and periods free from leakage. I think the present widespread tendency to sacrifice the normal pelvic floor and sphincters and to mutilate the abdominal wall with an unnecessary colostomy is inexcusable, and I have now transplanted or otherwise eliminated over 60 abdominal colostomy openings.

DIAGNOSIS OF ABDOMINAL CONDITIONS BY USE OF DRAINS

Diagnosis of abdominal conditions by the use of drains is a neglected phase of the subject. With the patient under local anesthesia and without removing him from his bed a small opening through the abdominal wall may be made by a trocar or scalpel and a narrow (6 mm.) suction drain introduced to nearly any part of the abdominal cavity. On aspiration the withdrawn fluid may at once indicate the diagnosis and the necessary treatment. The acid mucilaginous fluid from a perforated peptic ulcer, the blood from an ectopic pregnancy or lacerated liver, the beef broth fluid containing amylase from pancreatitis, the gas and intestinal contents from a damaged bowel, urine from a ruptured bladder, the milky pus of gonorrheal salpingitis, serum containing tubercle bacilli from tuberculous peritonitis or cancer cells from a malignant peritoneal indicate the advantage of drainage aspiration in the detection of intra-abdominal disease. Not only may the withdrawn fluid be diagnostic process but by continued aspiration through the drain the patient may be protected in a measure while preparations are being made for a necessary operation.

In the postoperative period aspiration drainage has indicated the development of an ileus hours before distress, abdominal distention, obstipation or obstructive vomiting has occurred by the sudden appearance of quantities of clear serum in the aspirating bottle. As soon as the obstruction has been overcome as by the use of a duodenal or Miller-Abbott tube the serous effusion rapidly subsides. Likewise the sudden appearance of fresh blood in the drain has given immediate warning of a postoperative hemorrhage while its sudden cessation has shown that the hemorrhage has ceased and that an operation was then not required.

DRAINAGE OR INTUBATION OF THE GASTROINTESTINAL CANAL

A Jutte or Levin nasal duodenal tube connected with a Wangermann suction apparatus is useful after partial or complete gastrectomy and

after operations on the intestinal tract. The Abbott-Rawson double tube also is used, one arm being inserted in the proximal and one arm in the distal loop of the jejunum connected with the stomach or the esophagus. When the wearing of such tubes is long continued, serious ulceration of the glottis, the pharynx and the upper part of the esophagus may occur and even necessitate tracheostomy. We consider it preferable, therefore, where a complete or nearly complete gastrectomy has been done on a patient with seriously impaired nutrition, to insert a 16 F catheter in the jejunum at the time of operation. The tube is fastened in place with two purse string sutures and the bowel also anchored to the overlying abdominal wall. With such a tube it is possible to feed the patient soon after the operation as well as to decompress the upper part of the intestinal tract.

With resections of the colon on the right, the contents being liquid an ileostomy rarely is required. Should distention develop aspiration on an indwelling duodenal tube usually is all that is necessary to relieve distention. With resection of the left half of the colon the content being semisolid, it is desirable to have a temporary proximal vent until the anastomosis is functioning properly.

The simplest procedure is an appendicostomy, a 16 F catheter being passed through the appendix. This may be done through a 1 or 2 cm transverse, stab wound incision. The hand introduced through the operative incision elevates the abdominal wall from the intestines at McBurney's point. A straight narrow bistoury is then thrust through the abdominal wall to the protecting fingers beneath, withdrawn and a curved Pean forceps substituted. The tip of the appendix is grasped under direct vision through the main wound. The appendix is withdrawn without dividing the mesoappendix, dressing applied to it, the appendix incised, and a 16 F catheter introduced through the appendix into the cecum, which is pulled up against the anterior abdominal wall. The appendix is ligated over the contained catheter with ligatures, each of which is tied over a dental cotton roll to prevent the appendical stump from retracting into the abdominal cavity. Gentle and frequent irrigations through the catheter are used in the early postoperative period every two to four hours. To break down solid fecal material a 10 per cent solution of hydrogen peroxide is substituted. Several days later, when it is desired to produce an evacuation, 150 cc of a 50 per cent glycerin solution is introduced through the catheter. This usually acts within ten or fifteen minutes. By the insertion of a larger catheter we have been able to introduce a 28 F tube in seven to ten days. If the appendix has been removed and is atrophic, a cone of loose cecum is grasped by the forceps and withdrawn through the small transverse stab wound at McBurney's point. Two purse string silk sutures are inserted, the mucosa exposed and covered under protection of surrounding gauze and a 16 F catheter is inserted.

tional holes is tied in with the two purse string sutures, which are likewise tied over dental cotton rolls at each side of the cone of bowel. By using a small incision there is little possibility for intra-abdominal leakage during the procedure. With persistent frequent gentle irrigations, such a simple appendicostomy or cecostomy usually will suffice to decompress a distended colon and eliminate the need of a formal preoperative colostomy.

An early postoperative intestinal obstruction not relieved by gastrointestinal intubation and not due to peritonitis rarely requires abdominal exploration. Differing from the obstruction due to a strangulation from a hernial ring or the firm adhesions present months or years after an abdominal operation, the stoppage results from an intestinal angulation due to recent and therefore soft and plastic adhesions. If separated, such adhesions often promptly reform, while if the distended bowel is adequately decompressed, the obstruction usually is permanently relieved. One therefore carefully locates, by contours and percussion, the most distended intestinal coil, exposes it through a short incision with the patient under local anesthesia and inserts a 14 F or 16 F catheter anchored as described for cecostomy.

SUMMARY

Abdominal drains may be selected to drain a limited part or the entire abdominal cavity, dependent on the adhesive reaction or lack of reaction they excite in the peritoneum. The most effective type of abdominal drainage is by continuous aspiration, as in the use of sump drains. Methods for stage drainage are given, as well as methods by which viscera are exposed by tubular drains to enable their continued observation or for a stage operation. The use of drains for preoperative and postoperative diagnosis, for the arrest of initial and recurrent hemorrhage and for the early detection of ileus and other conditions is described.

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PERITONEAL IRRIGATION FOR UREMIA FOLLOWING INCOMPATIBLE BLOOD TRANSFUSION

Report of a Case

E E MUIRHEAD, M D

A B SMALL, M D

AND

R B McBRIDE, M D

DALLAS TEXAS

PERITONEAL irrigation as a means of treating a patient with uremia resulting from acute renal damage following sulfathiazole therapy has been reported by Frank, Seligman and Fine¹. The same workers had previously observed the results of this technic on animal. Recently we utilized this method of peritoneal irrigation on a patient with uremia resulting from an incompatible blood transfusion. The procedure was effective and directly associated with improvement and subsequent recovery of the patient. The patient was not expected to survive, since grave sequelae of uremia existed. Moreover, certain complications related to the peritoneal irrigation were encountered. A report of the case therefore seems warranted.

REPORT OF A CASE

A white woman aged 36 years entered the hospital for a pelvic operation. A transfusion of whole blood was ordered prior to operation as a corrective measure for a moderate degree of anemia (red blood cell count 3,600,000 per cubic centimeter with a hemoglobin content of 9.9 Gm per hundred cubic centimeter). Through a clerical error the patient who was of type O Rh positive received blood from a type A₁ Rh positive donor. Approximately 175 cc of blood was given within twenty minutes before the reaction became pronounced. Recheck typing of donor and recipient established the gross incompatibility.

The course of the case is being divided into three periods.

1 *The Reaction and Development of Uremia (Sixteen Days)*—The patient first complained of nausea and generalized tingling sensations of the skin. Twenty minutes later the radial pulse and brachial blood pressure became imper-

From Baylor University Hospital

The assistance of Dr. Robert Bone (intern) and Dr. A. F. Halperin (resident) made the handling of this case possible.

1 Frank H. A., Seligman A. M. and Fine J. Treatment of Uremia by Means of Peritoneal Irrigation. *J. Clin. Investigation* 25: 211 (1946).

2 Seligman A. M., Frank H. A. and Fine J. Treatment of Uremia by Means of Peritoneal Irrigation. *J. Clin. Investigation* 25: 211 (1946).

Pronounced cyanosis was soon followed by a severe chill. Morphine sulfate ($\frac{3}{4}$ grain [10 mg]), atropine ($\frac{1}{10}$ grain [0.4 mg]) and epinephrine (75 minims [0.46 cc]) in a dilution of 1:1000 were given and ten minutes later the blood pressure was 144 systolic and 90 diastolic and the patient was clear mentally. Twenty-five minutes after the onset of the reaction the oral temperature was 102.2 F, the pulse rate was 100 and the respiratory rate was 25. Five hours later the temperature was 99.8 F, the pulse rate was 76 and the respiratory rate was 20. The patient vomited 500 cc of fluid at this time. The period of peritoneal irrigation lasted sixteen days (chart 1).

The first specimen of urine was dark red and was obtained at fifteen hours (30 cc). During the first seven days the average volume of urine in twenty-four hours was 101 cc. The volume of urine then gradually increased to 1850 cc on the sixteenth day, but the output of urea in twenty-four hours remained about 7 Gm.

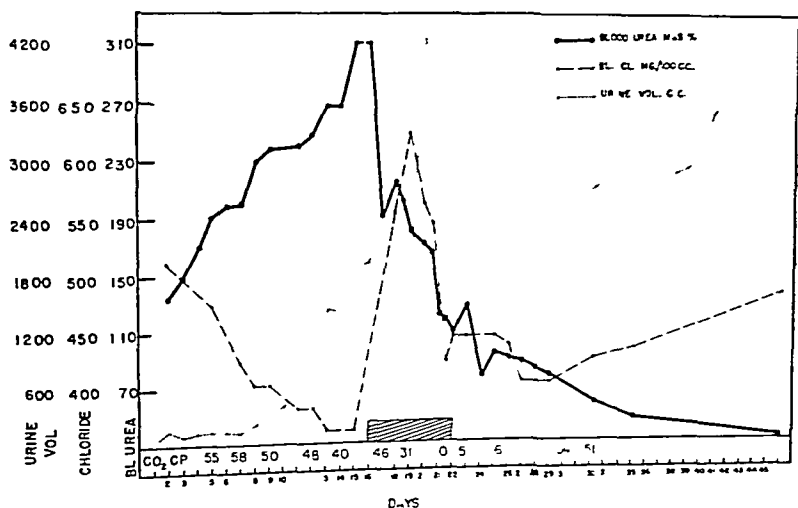


Chart 1—Changes in the blood urea concentration (milligrams per hundred cubic centimeters), blood chloride contents as sodium chloride (milligrams per hundred cubic centimeters) and daily volume of urine are represented. The thatched zone represents the period of peritoneal irrigation. Various levels of the carbon dioxide-combining power of plasma are indicated below the graph.

The sudden drop in the blood urea concentration during the first day can be partly explained on the basis of extracellular fluid dilution since the patient became more edematous and the blood chloride level was decidedly elevated. The turning point occurred in association with the diuresis and dehydration.

The oral temperature ranged between 99 and 101 F and the pulse rate was 100 from the tenth to the sixteenth day. Vomiting and retching continued through the entire period. During the sixteen days the volume of vomitus averaged 550 cc daily and consisted mainly of recently ingested water.

Pentobarbital sodium and morphine were used for mild sedation. The volume of fluid given intravenously amounted to 17,100 cc, all but 1 liter being given during the first eleven days (10,000 cc of 5 to 10 per cent dextrose in distilled water, 3,500 cc of whole blood, 500 cc of 5 per cent hypertonic solution of sodium chloride and 1,100 cc of 15 per cent amino acid solution to the environment was of the hot summer weather type). On the twelfth day the

digitalis was started and a total of $19\frac{1}{2}$ grains (1.26 Gm) was given prior to irrigation.

The patient's condition gradually deteriorated. The blood urea concentration steadily mounted from 134 mg per hundred cubic centimeters at thirty six hours to 310 mg per hundred cubic centimeters on the sixteenth day. The carbon dioxide-combining power of plasma gradually dropped from 58 to 40.5 volume per cent. The whole blood chloride contents (as sodium chloride) likewise decreased, from 510 mg per hundred cubic centimeters at thirty six hours to 360 mg per hundred cubic centimeters on the sixteenth day. The plasma protein concentration remained essentially unchanged (near 7.6 Gm per hundred cubic centimeters).

Gallop rhythm, apical systolic murmur and a loud pericardial friction rub appeared on the twelfth day. Generalized moist rales were present and became more pronounced. Mental dulness alternated with periods of emotional upset and irritability. Slight diarrhea and generalized muscular clonic spasms appeared on the fourteenth day. Generalized subcutaneous edema was distinct. The blood pressure which on admission was 120 systolic and 80 diastolic now reached 160 systolic and 110 diastolic in millimeters of mercury. The prognosis was considered poor and it was decided that a step such as peritoneal irrigation was warranted.

2. Period of Peritoneal Irrigation (Six Days).—With the patient under local anesthesia, a sump type drain was inserted into the peritoneal cavity in the lower right quadrant (McBurney's incision). A rubber catheter French no. 18 was inserted into the left upper quadrant through a trochar. During five and a half of the ensuing six days the peritoneal cavity was irrigated almost continuously with several types of crystalloid solutions. These solutions contained 1 mg of heparin and 25,000 units of penicillin per liter. Later streptomycin was used to combat mild peritonitis due to a gram-negative bacillus (*Proteus morganii*). A throttled Warren steen suction apparatus was used on the side in which the drain had been inserted and the flow was continuous. Penicillin 25,000 units intramuscularly every three hours was also given. In addition the patient received components of vitamin F and vitamin C parenterally.

During the irrigation 108,000 cc of fluid (about 19,500 cc per twenty-four hours) was introduced into the peritoneal cavity, and 92,805 cc was recovered. Much of the deficit appeared to result from leakage around the sump drain. A total of 76.85 Gm of urea was known to be recovered in the fluid (average 13.96 Gm per twenty-four hours). The loss through leakage may have amounted to 10 to 11 Gm of urea as the average urea concentration in the recovered fluid was 84.8 mg per hundred cubic centimeters (a range of 58 to 133.5 mg per hundred cubic centimeters).

The output of urea in the urine amounted to near 5 Gm on the first two days and about 12 Gm per day thereafter. The combined known urea output (peritoneal fluid and urine) for the six day period was 140 Gm.

During the first three days the irrigating solution consisted of Ringer's malian Tyrode solution (70 per cent of volume used) and isotonic solution of three chlorides (30 per cent of volume) except for 4 liters of lactate Ringer's solution used on the third day. During the fourth day only 5 per cent of lactate in distilled water was used for irrigation (discussed later). Thereafter 5 per cent dextrose in distilled water was alternated with isotonic solution of sodium chloride and lactate-Ringer's solution for irrigation.

The substantial drops in the blood urea concentration as seen in the subsequent periods of irrigation are shown in chart 1. Several complications, although apparent good progress made in this direction during the early phase of the

Cardiac irregularities were found to be due to the effect of digitalis and the administration of digitalis was discontinued. The patient coughed up scanty amounts of sputum which was blood tinged and pulmonary infarcts were suspected. When the pulmonary edema disappeared roentgenograms of the chest revealed no evidence of larger infarcts.

During the first three days of the irrigation the volume of urine decreased. The pulmonary and subcutaneous edema became more pronounced, and the whole blood chloride contents were elevated to 620 mg per hundred cubic centimeters while the patient received only 12 Gm of hypertonic solution of sodium chloride by vein. Need for correction of the progressive overhydration became acute; therefore, a regimen of dehydration was instituted by irrigation of the peritoneal cavity with a solution of 5 per cent dextrose in distilled water. This procedure was

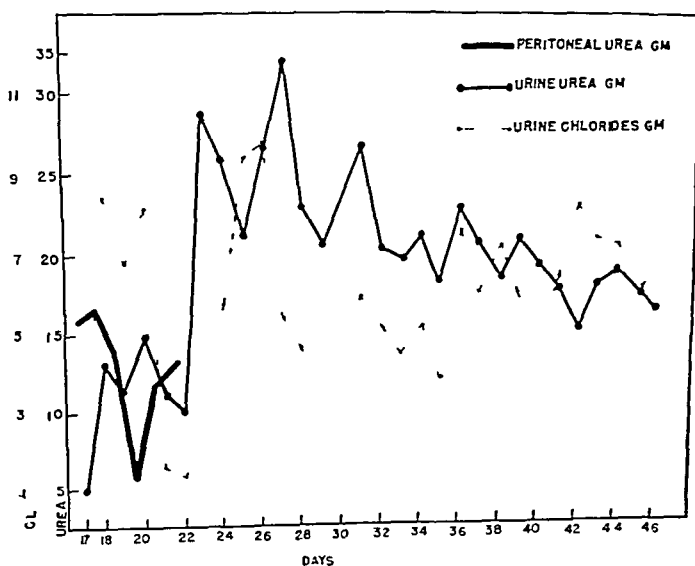


Chart 2—The output of urea (grams) via the urine and peritoneal washing fluid is indicated. The urine chloride output (sodium chloride as grams) is also described.

It can be noted that usually more urea was recovered via the peritoneal route. The sudden drop in peritoneal urea output occurred on the fourth day when the washings were discontinued for twelve hours.

The second period of diuresis occurred after the irrigation was discontinued and was associated with substantial urea output. The urine chloride output became prominent during the irrigation but dropped decidedly after the apparently induced diuresis. The latter is considered as additional evidence of dehydration by dextrose in distilled water.

continued for twenty-four hours. During this period the fluid was observed to enter the peritoneal cavity as 5 per cent dextrose in distilled water and to be recovered as 25 per cent dextrose in 0.42 per cent solution of sodium chloride. A copious diuresis occurred during this time (4375 cc in twenty-four hours) and the patient began to show signs of dehydration. It was estimated that the patient lost between 60 and 70 Gm of sodium chloride through the two routes during this period. The skin became dry and displayed loss of turgor and pallor.

monary sales almost completely disappeared, remaining only to a slight extent at the bases. The blood chloride concentration dropped decidedly. The patient showed a striking clinical improvement but now displayed evidence of much loss of weight. The blood pressure was 125 systolic and 80 diastolic in millimeters of mercury. The blood urea concentration continued downward.

The irrigation was now continued with salt solutions. The volume of urine continued down and reached 1,700 cc in twenty-four hours within two days. The peripheral hemoglobin concentration which had been 10.8 Gm per hundred cubic centimeters now became 15.0 Gm. The skin became cold and clammy, the radial pulse was weak, 130 per minute and the brachial blood pressure was 104 systolic and 60 diastolic in millimeters of mercury. The carbon dioxide-combining power was 30 volumes per cent. The patient now demonstrated signs of peripheral circulatory failure due to dehydration and peritonitis (see following paragraph). It was considered advisable to administer the following fluids by vein: 1,000 cc of normal plasma, 1,000 cc sodium *r*-lactate one-sixth molar solution, 500 cc of whole blood and 1,000 cc of 5 per cent dextrose with 45 Gm of amino acids. Improvement occurred and the blood pressure was elevated to 104 systolic and 60 diastolic in millimeters of mercury. The following day 1,000 cc of normal plasma was given by vein, the blood pressure remained 120 systolic and 82 diastolic in millimeters of mercury, and the peripheral hemoglobin concentration rose off at 10 to 11 Gm per hundred cubic centimeters.

On the fifth day of irrigation the recovered fluid was found to contain prominent numbers of polymorphonuclear neutrophilic leukocytes with engulfed bacteria. A culture revealed a prominent growth of a gram negative bacillus identified as *P. morganii*. Streptomycin therapy was initiated 0.5 Gm intramuscularly every three hours and 1 Gm into the peritoneal cavity daily. There was no discharge. The peritonitis was readily controlled by this regimen. All tubes were removed seven days after the irrigation was started.

3 Postirrigation Period of Convalescence (Twenty-Four Days).—Control of the peritoneal inflammation and correction of the dehydrated state were effected by a sustained diuresis. The output of urea in the urine varied between 31.6 Gm per twenty-four hours for nine days and then slowly receded to 1.5 Gm daily. The output of chloride in the urine was elevated during this period. Blood urea, chloride and carbon dioxide-combining power of plasma level reached normal values. The patient improved decidedly and ate heartily of a regular diet soon after the irrigations were discontinued.

The sump drain was removed first. Through the catheter on two occasions 1 Gm of streptomycin was introduced into the peritoneal cavity with 100 cc of isotonic solution of sodium chloride. The catheter was removed. The wound healed rapidly. Intramuscular administration of penicillin and streptomycin (10 units and 0.5 Gm) was discontinued five and ten days respectively after irrigation was discontinued.

The volume of urine per twenty-four hours continued between 2,000 and 3,000 cc until the patient left the hospital thirty-eight days after the start of irrigation. The urea clearance at this time was 53 per cent of normal. Other vital functions were well on the road to completion.

COMMENT

It can be considered that this patient may have recovered from the aid of extrarenal blood-clearing procedures, since the volume of urine had steadily increased to 1,850 cc per twenty-four hours.

eral features however, seem to oppose this view. The specific gravity of the urine remained low (table) and even with a volume of urine of 1,400 to 1,850 cc the urea output did not exceed 20 to 25 per cent of normal despite a high urea load in the body. Moreover during the sixteen day period the patient's clinical course was progressively downward. The azotemia pointed steadily upward. Signs frequently attributed to advanced and grave uremia appeared. These included mental cloudiness, generalized clonic muscular spasms, enlarged heart gallop rhythm apical systolic murmur and a loud pericardial friction rub, advanced pulmonary edema, prominent subcutaneous edema, pronounced azotemia vomiting, slight diarrhea and hypertension. It appeared likely, therefore that the patient might succumb before the hoped-for diuresis occurred.

Results of a Series of Urinalyses

Day	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Diabetic Acid	Casts	Red Blood Cell	White Blood Cell
1	1.010	Acid	600	None	None	Negative	None	Many	Many
2	1.014	Neutral	20	None	None	Negative	None	Moderate	Many
	1.016	Alkaline	60	None	None	Negative	None	None	Many
8	1.007	Neutral	450	None	None	Negative	None	Few	Loaded
9	1.007	Neutral	100	None	None	Negative	None	Many	Many
12	1.008	Neutral	75	None	None	Negative	None	Rare	Loaded
17	1.005	Alkaline	75	None	None	Negative	None	Few	Loaded
18	1.011	Neutral	100	None	None	Negative	None	Rare	Many
21	1.010	Neutral	50	None	None	Negative	None	Occasional	Occasional
22	1.009	Neutral	0	None	None	Negative	None	Rare	Many
28	1.009	Neutral	50	None	None	Negative	None	Occasional	Many
30	1.008	Neutral	0	Trace	None	Negative	None	Few	Few
42	1.008	Neutral	10	Trace	None	Negative	None	Rare	Few
46	1.010	Neutral	Trace	None	None	Negative	None	Few	Occasional

Much of the patient's difficulties could be attributed to overhydration. The administration of hypertonic solution of sodium chloride (5 per cent sodium chloride) was followed by an aggravation of the clinical appearance. It was hoped that the peritoneal irrigation procedure would be attended by an amelioration of the generalized edema since such was observed by Frank Seligman and Fine when no fluids were given intravenously to their patient. Tyrodes solution and isotonic solution of three chlorides being used for irrigation the amount of urea recovered from the patient was comparable to that obtained by these observers yet distinct enhancement of the already overhydrated state occurred. The subcutaneous and pulmonary edema became more pronounced and the blood chloride concentration was decidedly elevated. At the same time the patient's serum potassium concentration was raised.

3. Pest C. H. and Taylor N. F. The Physiological Basis of Metabolism, 2nd ed. Baltimore: Williams & Wilkins Company, 1945, p. 347.

to be normal (4.84 milliequivalents per liter). The patient's oral intake could not account for these changes. The maintenance of a normal potassium concentration extracellularly could be accounted for on the basis of cellular shift⁴ or by absorption from the peritoneal fluid. The large volumes of Tyrode's solution and isotonic solution of three chlorides accounted for much potassium chloride. All the various changes (increase in edema, increase in blood chlorides and normal serum potassium concentration unaccounted for by oral intake) could be better explained as due to absorption by the peritoneal surfaces. The body apparently continued to absorb Tyrode's solution and isotonic solution of three chlorides despite the existence of waterlogging.

Clearcut results were obtained in this case by the use of 5 per cent dextrose in distilled water by the peritoneal route. This procedure was associated with a copious diuresis (4,375 cc per twenty-four hour). Even so, the amount of urea recovered in the urine was not much greater than that in the peritoneal washings (a total urea level of 26.6 Gm for the twenty-four hour period). Moreover, the urine chloride concentration was low, and 90 per cent of the sodium chloride lost from the body during the dehydration period escaped through the peritoneal fluid. Two main changes seemed to occur: (1) the exchange of dextrose for salt through the peritoneal surface, as in the experiment of Darrow and Yannet,⁵ accounting for most of the loss of salt, and (2) the loss of substantial water volume through the kidneys, as in a glucose type diuresis.

Whether the ability for diuresis was made possible as a result of the three days of peritoneal irrigation and rest of the kidney cannot say. Certainly diuresis was not possible following the administration of dextrose in distilled water by vein prior to the irrigation. It may well be that an avenue for loss of salt was needed which was served by the peritoneal washings.

The dehydration was considered the turning point in the progress of this patient. Outstanding clinical improvement accompanied the water-sodium chloride loss. The edema disappeared, the lungs became clear. There was prominent mental improvement, and the patient began partaking of a general diet. Two other complications were to be evident before recovery could be assured.

Low grade peritonitis without ileus developed. The only complication was associated with signs of forward circulation due to oligemia. It was considered that the state of decreas-

4 Darrow, D. C. The Retention of Electrolyte During Recovery from Dehydration Due to Diarrhea. *J. Pediat.* 28:515 (May) 1946.

5 Darrow, D. C. and Yannet, H. The Changes in the Distribution of Water Accompanying Increase and Decrease in Extracellular Fluid. *Investigation* 14:266 (March) 1935.

water plus the inflammatory edema of peritoneal structures was causative. The complication was readily controlled by the intravenous administration of blood plasma and electrolytes and water and streptomycin. Subsequent recovery was rapid.

The patient left the hospital capable of ambulation. As in the case of Frank, Seligman and Fine,¹ the urea clearance level on discharge was still well below normal (53 per cent of normal).

SUMMARY

A case of uremia following the acute renal damage due to an incompatible blood transfusion is presented. The prognosis seemed poor until the procedure of peritoneal irrigation was instituted according to the technic of Frank, Seligman and Fine.¹ The amount of urea cleared from the body by this procedure was comparable to that reported by these observers. The urea clearance was taken as a measure of the clearance of other substances.

Overhydration constituted one of the main complications as the kidneys were not able to discard water. This complication was accentuated in this case by the use of Tyrode's solution and isotonic solution of three chlorides in the peritoneum. Recovery was associated with the loss of water and salt from the body while dextrose in distilled water was used for peritoneal irrigation.

Substantial amounts of urea were obtained by this method, and the azotemia was greatly relieved. Subsequently the kidneys cleared large quantities of urea from the body but polyuria was necessary as the urea clearance remained depressed.

A low grade of peritonitis was associated with the signs of oligemia. Additional evidence of oligemia operating was obtained by the prompt recovery following administration of blood plasma and electrolyte solution by vein.

CONCLUSIONS

1 Peritoneal irrigation for the clearance of urea and presumably other substances and sodium chloride from the body in a case of uremia following an incompatible blood transfusion was found to be effective and directly related to recovery of the patient.

2 Certain complications related to this procedure are discussed.

ADDENDUM

Since this report was completed Fine, Frank and Seligman have reported additionally on this procedure.

1 Fine J, Frank H A and Seligman A M. The Treatment of Acute Renal Failure by Peritoneal Irrigation. *Ann Surg* 124: 557 (Nov.) 1946.

PERMANENT INTUBATION OF THE THORACIC AORTA

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SINCE the first reported permanent anastomosis of a blood vessel by Eck,¹ many efforts have been directed toward the discovery of improved technics for the union of blood vessels. The contribution of Jassinowski,² Dorfler,³ Briau and Jaboulay,⁴ and Watts⁵ were important steps in the development of successful methods of suture. The work culminated by the painstaking work of Carrel and Guthrie⁶ in the year 1905 to 1912. The technic which they evolved has been highly successful in experienced hands and remains the basis of present methods.

✓ However, during the period in which suture technics were developing, the search for simpler and more rapid methods continued along other lines. As early as 1897 Nitze⁷ advocated the use of an iron ring. Through this ring a vessel was threaded, and after the edge was everted, the vessel and the ring were passed into the open end of the vessel and tied in place with a ligature. Because of the reaction to the material employed, this method usually gave rise ultimately to thrombosis and it never became generally used.

Pavlov⁸ first advocated the use of magnesium rings similar to those of Nitze and later the use of flanged magnesium tubes with pinlike

From the Laboratory of Surgical Research, Harvard Medical School.

1 Eck, N. N. On the Ligature of the Portal Vein. *Memorie di Chirurgia*, vol. 130.

2 Jassinowski, A. Die Arteriennaht eine experimentell chirurgische Inaug. Dissert. Dorpat 1889.

3 Dorfler, H. Ueber Arteriennaht. *Beitr. z. klin. Chir.* 25: 71, 1907.

4 Briau, E. and Jaboulay. Gastro-entero-anastomose d'un caecum et du plasma de l'estomac. *Lyons med.* 83: 380, 1896.

5 Watts, S. H. Suture of Blood Vessels. *Implantation and Transplantation of Vessels and Organs. An Historical and Experimental Study*. J. Hopkins Hosp. 18: 153-179, 1907.

6 Carrel, A. The Surgery of Blood Vessels etc. *Bull. Jol. Hosp.* 18: 18-28, 1907. Technique and Remote Results of Vascular Anastomosis. *Gynec. & Obst.* 14: 246-254, 1912. Guthrie, C. C. *Blood Vessel Surgery. Application*. London: Longmans, Green & Co., 1912.

7 Nitze, F. Kleinere Mittheilungen. *Kongress in Monat. Chir.* 24: 1042, 1897.

jections on one side and holes to receive them on the other which approximated intima to intima when the two halves were united. He stated the belief that because magnesium disappeared when left in the tissues it was an ideal substance for this purpose. However it is now known that magnesium strongly stimulates production of fibrous tissue and would induce obliteration of the lumens of the vessels. Because this method was so rarely successful, it was soon abandoned.

Tuffier⁹ attempted to use paraffined silver tubes to bridge arterial gaps during World War I but thrombosis invariably followed. Although this usually occurred in about twenty-four hours the tubes sometimes remained patent for several days so that collateral circulation was established. From this, Tuffier expressed the opinion that he was able to avoid amputation in several instances.

In spite of obtaining excellent results with suture technics Alexis Carrel¹⁰ continued to seek a satisfactory intubation method. He attempted to bridge gaps in the thoracic aorta with tubes of glass, aluminum and gold plate, all of which resulted in thrombosis. He suggested that if these tubes were lined with segments of vein successful results might be obtained but he did not report a trial in animals.

More recently Blakemore, Lord and Stefko¹¹ and Blakemore and Lord¹² introduced their vitallium tube technic which incorporated the principles of Nitze's ivory rings with the venous graft as originally suggested by Carrel.

A similar technic was used by Crile, Bernheim and Elsberg^{12a} in direct transtusions and temporary union of an artery to a vein. The

8 Pavr E. Beiträge zur Technik der blutgefässund Nervenreht Mittheilungen über die Verwendung eines resorbirbaren Metalles in der Chirurgie. Arch f klin Chir **62** 67-93 1900. Zur Frage der circulären Vereinigung von Blutgefässen mit resorbirbaren Prothesen. ibid **72** 32-54 1904.

9 Makins G H. Gunshot Injuries to the Blood Vessels. London: John Wright & Sons 1919.

10 Carrel A. Permanent Intubation of the Thoracic Aorta. J Exper Med **16** 17-24 1912. Results of the Permanent Intubation of the Thoracic Aorta. Surg Gynec & Obst **15** 245-248 1912.

11 Blakemore A H, Lord J W Jr and Stefko P L. Severed Primary Artery in War Wounded: Non Suture Method of Bridging Arterial Defect. Surgery **12** 488-508 1942. Restoration of Blood Flow in Damaged Artery. Further Studies on Non Suture Method of Blood Vessel Anastomosis. Arch Surg **117** 481-497 1943.

12 Blakemore A H and Lord J W Jr. A Non Suture Method of Blood Vessel Anastomosis. Ann Surg **121** 435-455 1945.

12a Bernheim B M. Surgery of the Vascular System. Philadelphia: J B Lippincott Company 1913.

method of Blakemore and colleagues¹³ is reported to be uniformly successful in the hands of surgeons experienced in its use. The use of the inert metal vitallium would appear to be the key to its success. However, a high percentage of thrombosis was experienced with this method in military use, necessitating heparinization and adding to the difficulties of the technic¹⁴.

The use of glass cannulas for temporary restoration of blood flow in several vessels is reported to have some success as long as the patient is kept on adequate doses of heparin¹⁵. The fragility of the tube, the necessity of a second operation and the thrombosis which follows the omission of anticoagulant therapy as well as the complications of heparinization itself are factors which reduce the efficiency of this technic.

However, it is desirable, if possible, to avoid the use of a venous graft in bridging arterial defects, as this would greatly simplify the procedure and make it more applicable to emergencies. With such a technic, certain characteristics are necessary in a tube which is to be used to bridge arterial defects: 1. It must be strong. 2. The junction between the tube and the vessel must be smooth. 3. The lumen must be extremely smooth. 4. It must be well tolerated by tissues. 5. Ideally it must approach the elasticity of the vessel for which it substitutes and be rigid only at the points of junction.

With the developments of the many new plastics, some of which are known to be relatively inert in tissue, an investigation of the properties of some of the most promising was undertaken. Methyl methacrylate (lucite) appears to meet the requirements most closely. This polymer is well tolerated by tissues, has a high tensile strength, has a negligible water absorption, is easily worked and is inexpensive. It was also found to have the highly desirable property of delaying the coagulation of blood. Hirschboeck¹⁶ found that blood placed in vessels of this material has a prolonged coagulation time and that clot retraction is delayed or does not occur. Neubauer and Lambert¹⁷ postulated that other factors being excluded the coagulation time is inversely propor-

13 Blakemore Lord and Steiko¹¹ Blakemore and Lord¹²

14 Cutler E. C. Personal communication to the author May 1946

15 Bailey H. Surgery of Modern Warfare Baltimore Williams & Wilkins Company 1944

16 Hirschboeck J. S. Delayed Blood Coagulation and Absorption of Blood in Collodion Lined Vessels Proc Soc Exper Biol & Med 43: 124 1940 Delayed Blood Coagulation in Methyl Methacrylate (Probably Lucite) Vessels ibid 47 311-312 1941

17 Neubauer, O. and Lampert H. Ein neuer Plättchenersatz. Ein Beitrag zur Kenntnis der thrombogenen Eigenschaften der Plättchen. München med Wchn chr 77 582 586 1930

tional to the adhesive force between blood and the surface with which it is in contact. Methyl methacrylate has a pronounced water-repellent surface and this property appears to be enhanced when the tube is highly polished. Thus, this material appeared to fulfil the majority of the theoretic requirements and a series of experiments was undertaken.

The thoracic aorta was selected as the site for the procedure because no known permanent intubation technic has been successful because of our interest in coarctation of the aorta¹⁸ and because in this critical position failure is immediately heralded by sudden death.

The tubes used in this study were machined from blocks or cylinders of methyl methacrylate. The ends were tapered from the inside to form thin, smooth, but not cutting leading edges. They were 4 cm long and the walls were 1 mm thick. Two grooves 3 mm wide were placed at each end and were separated by a ridge 1 mm above the remaining surface of the tube. The end groove began 1 mm from the end of the tube. These grooves were adequate to accommodate the ligature material employed, and the ridge prevented slipping of the ligature without adding unduly to the diameter of the tube. Tubes were made 1 cm and 1.3 cm in diameter to accommodate the variation in aortic size in different animals. The inner aspect of the tube received most careful attention being polished to an extremely smooth finish with finest jeweler's rouge. No imperfections of this surface were tolerated.

LABORATORY PROCEDURE

Fifteen mongrel dogs weighing 18 Kg or more were used. Operations were performed with the animals under positive pressure anesthesia induced with ether administered intratracheally. A left anterolateral incision was made in the third interspace and the third and fourth costal cartilages were cut. The left lung was allowed to partially collapse and was carefully walled off with moist pads. The aortic arch and the descending thoracic aorta were dissected from the surrounding structures extending from the subclavian artery to the first pair of intercostal arteries. These were then ligated and divided as were the second and occasionally the third pair. Unless care is taken these vessels can be torn close to the aorta with considerable hemorrhage ensuing. When the aorta was completely mobilized it was occluded proximally and distally by arterial tourniquets of cotton tape spaced 6 to 8 cm apart. The proximal tourniquet was placed first and slowly tightened to avoid fracture of the vessel. Tourniquets of this type were employed because they seldom slip and they cause minimal trauma to the wall of the vessel. In no instance was there evidence of damage to the aorta when the vessel was examined later. They also provide good control after the aorta has been sectioned.

¹⁸ Crafoord C and Nelin G. Congenital Coarctation of Aorta and Its Surgical Treatment. *J Thoracic Surg* 14:3-7 3rd 1945. Gross K E and Hummel C A. Coarctation of the Aorta. *New England J Med* 233:287-293 1945.

Immediately after the tourniquets were placed the vessel was completely sectioned and a segment 1 to 3 cm was excised. Three arterial stay sutures were quickly placed in each end of the vessel. A tube of proper size was carefully inserted into the proximal end and tied in place with two strands of U S P no 2 braided silk, the distal one of these was tied snugly and the proximal one just tight enough to hold the tube firmly. A similar procedure was then carried out at the other end of the vessel. A fine needle was then inserted into the lumen of the tube through the wall of the vessel and the air evacuated and replaced with a solution of sodium chloride. The distal tourniquet was removed first and then the proximal. The latter was removed slowly to allow for compensatory circulatory changes. The time of aortic occlusion was always under ten minutes.

Results of Intubation of the Thoracic Aorta in Dogs

No	Time of Survival	Cause of Death	Condition of Tube	Comment
1	6 hr	Shock	No clot	Ligatures small difficulty in placing tube
2	6 days	Empyema	No clot	Ligatures intact good vascular result
3	2 days	Pneumonia	No clot	Ligatures intact good vascular result
4	6 days	Hemorrhage	No clot	Ligatures small cut through over the junction of vessel
5	1 day	Shock	1 mm clot on edge of tube	Difficulty in placing tube
6	6 mo	Killed	No clot	Ligature large not braided good vascular result
7	8 days	Hemorrhage	No clot	Ligature large, not braided cut through
8	6 wk	Killed	No clot	Ligature large braided good vascular result
9	7 day	Hemorrhage	No clot	Ligature large, not braided cut through
10	6 mo	Killed	No clot	Ligature braided good vascular result
11	1 day	Acute dilatation of stomach	No clot	Ligature braided good vascular result
12	6 mo	Killed	No clot	Ligature braided good vascular result
13	10 days	Hemorrhage	No clot	Ligature large not braided cut through
14	4 mo	Killed	No clot	Ligature braided good vascular result
15	6 days	Hemorrhage	No clot	Ligature braided cut through at junction

could usually be accomplished in five to six minutes. This is within the limit tolerated by unprepared dogs without damage to the cord or cerebral effects. When the ligatures were properly placed there was no bleeding over.

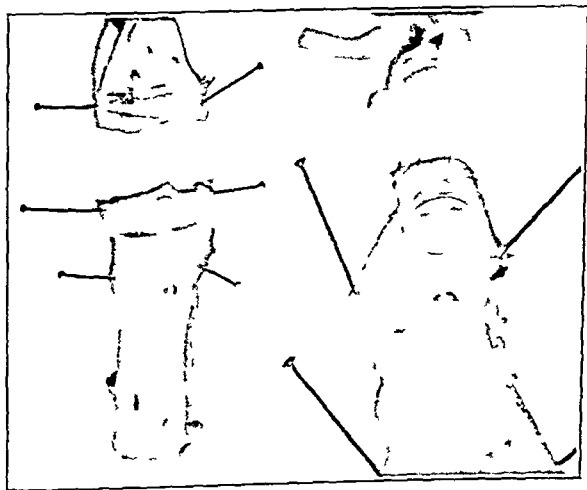
In several animals the aorta was not completely covered but was intubated two thirds of its circumference and the tube tied in place in the same manner. A segment of the vessel was then excised from around the tube and the circulation had been reestablished. In this way the time of aortic occlusion was reduced to three to four and a half minutes. This method could be readily adapted to traumatized peripheral vessels as well as to the aorta.

Following reestablishment of the circulation the pleura was closed and the aorta. The lung was reexpanded by aspiration of the air from the pleural space and the chest was closed with interrupted silk sutures. It was found that no form of anticoagulant therapy was employed and a satisfactory result

COMMENT

The thoracic aorta presented the problems encountered in peripheral vessels but in addition had certain factors peculiar to itself. The force of arterial pulsation and tendency to retraction are extreme. Friability of the wall is considerably greater here than elsewhere in the arterial tree and presents a major problem. To meet this several types of tubes and ligatures were tried before uniformly successful results were obtained and the reported form adapted.

Broad ligature material was used from the beginning of the series of experiments but in spite of this ligatures frequently cut through the wall of the vessel in from seven to ten days. Five dogs died of secondary



Thin layer of fibrous tissue surrounding the tube. Note the absence of clot in the vessel and tube.

hemorrhage due to this cause. Heavy braided silk and cotton tape were used, with little improvement in results. In an effort to evolve a more satisfactory type of ligature a braid of three strands of U. S. P. no. 2 braided silk was tried and the grooves in the tube widened to accommodate this ligature. With its use there was little further difficulty with cutting through of the ligature. This braid gave multiple point fixation without producing necrosis of the circumference of the wall.

When the tube was to be introduced great care was exercised to prevent injury to the intima of the vessel during its manipulation. This precaution has been recognized by all who have worked with intubation technique. At the outset of the experiments thrombosis of the vessel was expected to give greatest difficulty. However, it did not occur in a single

animal of the series. In 1 animal empyema (streptococcic) occurred postoperatively but in spite of this the tube was functioning well, without evidence of beginning thrombosis two weeks after operation. Several animals in the latter part of the series were allowed to survive for six months and throughout this time showed normal activity and maintained normal femoral pulsation.

✓ All animals were examined at autopsy, at which time the tube and vessel were firmly connected and could not be separated except by sharp dissection. The tube was surrounded by a thin layer of fibrous tissue and immediately adjacent to the tube there was a layer of flattened cells resembling endothelium which appeared to be continuous with the endothelium of the vessel (figure). The junction of the edge of the tube and the vessel was smooth, and the endothelium of the artery formed a smooth union with no irregularity. In 1 of the animals during one day after operation a fleck of fibrin was found deposited on the artery wall at the proximal end of the tube. This was not larger than 1 mm.

The technic of replacing segments of the thoracic aorta appears to be satisfactory in dogs and should be applicable to large vessels in human beings down to the size of the femoral artery. The possibilities for use in replacing traumatized arterial segments and bridging arterial defects are obvious. It may also be applicable for repair of certain arteriovenous fistulas and aneurysms and in venous anastomosis.

It also appears probable that methyl methacrylate polymer can be used instead of vitallium in an anastomosis of the type used by Blaisdell and associates and would be considerably more economical. To many other possibilities for its use include the replacing of esophageal and ureteral segments.

However all vascular intubation technics or non-suture methods using nonabsorbable materials have the undesirable characteristics of being unable to enlarge to meet increasing physiologic demands and are somewhat limited in their use, particularly in children. The use of a vascular graft coupled with an inert absorbable tube does not solve this difficulty. Thus a venous or arterial segment preserved by refrigeration could be used to bridge a vascular defect and anastomosed to the artery with a rigid tube which would ultimately be absorbed making it possible for the site of union to increase in size. Late in 1944 an attempt was made to obtain fibrin film in tube form but due to the exigencies of the war none was available. The potentialities of this method were brought to the attention of Dr. Cohn, of the Department of Physiology. It was suggested that plasticized fibrin tubes might be made from tubes or rolled film and it is hoped that the current work will

SUMMARY

A brief review of nonsuture technics of vascular anastomosis is presented. A technic is described for permanent replacement of segments of canine thoracic aorta which functioned satisfactorily with the use of anticoagulants. These experiments gave evidence that such a technic may be practical for use in replacing segments of the aorta and large arteries in human beings and that tubes of methyl methacrylate have many potentialities in vascular operation.

elective operations were performed. The latter surgical procedures included partial gastrectomy, anastomotic operations and total gastrectomy. For purposes of brevity the latter group of cases is referred to as the group of resections. The period of observation coincides roughly with the latter half of the war period, during which there were widespread social and economic dislocations. The results doubtless reflect these influences.

ETIOLOGIC FACTORS

Race—It commonly is believed that peptic ulcer predominates in the Caucasian race. A corollary is the belief that it occurs infrequently in other pure or mixed races. In a previous report by one of us² 94.3 per cent of cases were found to occur in the Caucasian race, 4.8 per cent in the Ethiopian, 0.28 per cent in the Indian and 0.57 per cent in the Algonquian race. DeBakey,³ in cases collected from the Charity Hospital, New Orleans, found 60.6 per cent in the white race and 39.3

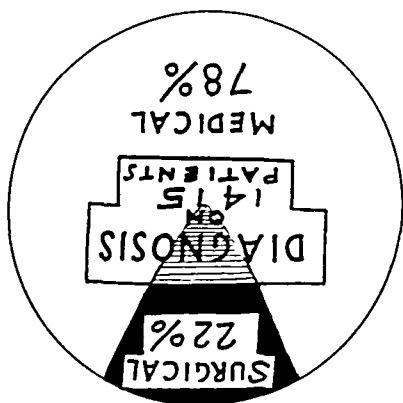


Chart 1—Diagnosis of peptic ulcer at the Los Angeles General Hospital for the period of two and one-half years from Jan. 1, 1943, to June 30, 1945. The study includes 100 unselected cases of acute perforation and 50 unselected cases of resection.

per cent in the "colored race." The inference is that the latter refers to the Negro race. In the present series (table 2) 87 per cent of the group of acute perforations and 86 per cent of the group of resections occurred in Caucasians. Whereas in the group of acute perforations there were no mixed (Mexican) and East Indian races represented, there were 4 and 2 cases respectively in the group of resections.

- 2 Thompson H L. Acute Perforation of Peptic Ulcer. An Evaluation of Contributors and Evolving Causes. Surg Gynec & Obst 64: 863-871, 1937.
- 3 DeBakey M. Acute Perforated Gastrointestinal Ulceration. A Statistical Analysis and Review of the Literature. Surgery 8: 352-364, 1-1 1928-1937.

ANATOMIC LOCATION OF ULCER

Considerable diversity of opinion exists regarding the frequency of the several sites of acute perforation. In our previous series² 60.9 per cent of the perforations were in the anterior wall of the stomach or duodenum. In the series from Charity Hospital, DeBakey³ found 52.3 per cent of the perforations to be duodenal. In his collected series

TABLE 3—Anatomic Location of Peptic Ulcer Requiring Surgical Treatment

	Acute Perforation %	Resections and Other Procedures %
Duodenum	53	66
Stomach	46	32
Marginal	1	2

of 11,305 cases, 51.2 per cent of the perforations were duodenal. In the present study (table 3) 53 per cent of the acute perforations occurred in the duodenum, 46 per cent in the stomach and 1 in a marginal ulcer. Toland and Thompson⁴ previously have reported on acute perforation of gastroduodenal ulcer.

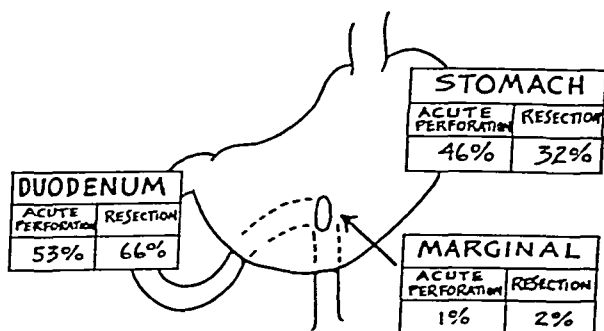


Chart 3—Anatomic location of peptic ulcer treated surgically

PREVIOUS TREATMENT

It frequently is stated in the literature on peptic ulcer that surgical treatment becomes necessary because of failure of medical treatment. More accurately, it should be said that operation usually is necessary because of the absence or failure of a program, be it one or no treatment, of medical treatment, of previous surgical treatment or of combinations of two or more forms of treatment. Referring to the group of acute perforations in this study (table 4), one finds that there was no record of any previous treatment in 78 per cent of the cases. Previous medical treat-

⁴ Toland C G and Thompson H I. Acute Perforation of Gastroduodenal Ulcer. Ann Surg 104 827-832 1936

Sex—In 1937 one of us² reported that in our series acute perforation occurred in men in 94.2 per cent of cases. DeBakey³ in 1941 found that 92.2 per cent occurred in men. In this study (table 2) there were men totaling 87 per cent in the group of acute perforations and 82 per cent in the group of resections. Our present study therefore indicates an increase in the number of women affected with surgical peptic ulcer.

TABLE 2—*Etiologic Factors in Peptic Ulcer Requiring Surgical Treatment*

	Acute Perforation %	Resection and Procedures %
Race		
Caucasian	87	86
Age		
4th and 5th decades	54	
5th and 6th decades		
Sex		
Male	87	82

Age—In our previous series of 500 cases there were 52.2 per cent occurring in the fourth and fifth decades combined. In the decades next younger and next older, namely, the third and sixth combined, there were 32.8 per cent of cases. In other words, 85.0 per cent of the cases occurred in the third to sixth decades inclusive.

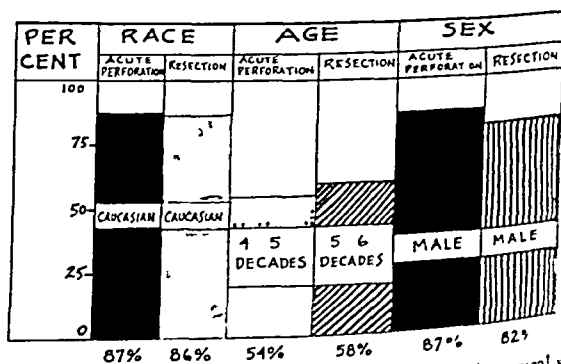


Chart 2—Etiologic factors in peptic ulcer treated surgically

In the present series (table 2) slightly over half of the acute perforations (54 per cent) occurred in the fourth and fifth decades. Similarly, in the group of resections 58 per cent occurred in the fifth and sixth decades. Moreover, 78 per cent of the acute perforations occurred in the fourth, fifth and sixth decades or later. Similarly, 82 per cent of the resections occurred in the fifth, sixth and seventh decades. Thus, in the majority of instances, patients come to require operation a decade later than the patients who require operation for acute perforation.

ANATOMIC LOCATION OF ULCER

Considerable diversity of opinion exists regarding the frequency of the several sites of acute perforation. In our previous series² 60.9 per cent of the perforations were in the anterior wall of the stomach or duodenum. In the series from Charity Hospital, DeBaey³ found 52.3 per cent of the perforations to be duodenal. In his collected series

TABLE 3—*Anatomic Location of Peptic Ulcer Requiring Surgical Treatment*

	Acute Perforation %	Resections and Other Procedure %
Duodenum	53	66
Stomach	46	32
Marginal	1	2

of 11,305 cases, 51.2 per cent of the perforations were duodenal. In the present study (table 3) 53 per cent of the acute perforations occurred in the duodenum, 46 per cent in the stomach and 1 in a marginal ulcer. Toland and Thompson⁴ previously have reported on acute perforation of gastrojejunal ulcer.

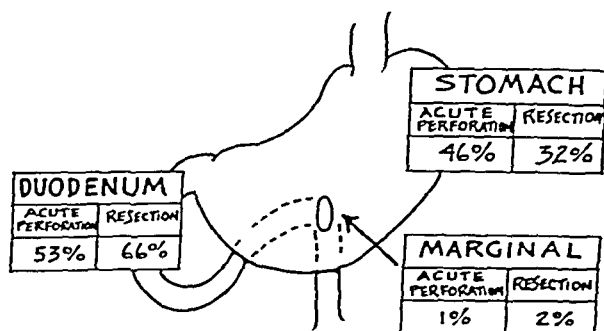


Chart 3—Anatomic location of peptic ulcer treated surgically

PREVIOUS TREATMENT

It frequently is stated in the literature on peptic ulcer that surgical treatment becomes necessary because of failure of medical treatment. More accurately, it should be said that operation usually is necessary because of the absence or failure of a program be it one or no treatment of medical treatment, of previous surgical treatment or of combinations of two or more forms of treatment. Referring to the group of acute perforations in this study (table 4), one finds that there was no record of any previous treatment in 78 per cent of the cases. Previous medical treat-

⁴ Toland C. G. and Thompson H. I. Acute Perforation of Gastrojejunal Ulcer. *Ann Surg* 104: 827-852, 1936.

ment was recorded in 17 per cent and previous surgical treatment in 5 per cent of the cases. In the group of resections there was no record of previous treatment in 16 per cent. There was, on the other hand, a record of previous medical treatment in 74 per cent, of previous surgical treatment alone in 10 per cent and of previous medical and surgical

TABLE 4—*Previous Treatment of Peptic Ulcer Requiring Surgical Treatment*

	Acute Perforation %	Resections and Other Procedures %
None	78	16
Medical	17	74
Surgical	5	10
Medical and surgical	0	-

treatment in 32 per cent of this group. In the last, surgical treatment was limited to suture of previous acute perforations, in 2 cases of which multiple (two) previous perforations had been sutured.

DIAGNOSIS

Confirmatory diagnostic procedure in this series of cases was limited to roentgenologic examination (table 5). In a previous publication one of us pointed out the diagnostic value in acute perforation of free

TABLE 5—*Diagnosis of Peptic Ulcer Requiring Surgical Treatment*

Roentgenologic Examination	Acute Perforation %	Resection and Other Procedures %
Used in	71	57
Diagnostic value	65	50
Free air	6	5
Obstruction		5
Penetration		5
Marginal ulcer		5
No diagnostic value		
Free air	24	4
Diagnosis carcinoma		

intraperitoneal air as demonstrated by roentgenologic examination. Roentgenologic examination was employed in the present study in 71 per cent of the acute perforations and in 90 per cent of the resections. In the latter group this statement applies only to recent roentgenologic examination of the stomach. In the 10 per cent of the cases in which recent examination was not recorded it had been used on a previous admission of the patient to the hospital. In the group of acute perforations roentgenologic examination was of diagnostic value in the demonstration of free intraperitoneal air in 66 per cent of the cases. On the other hand it was not of diagnostic value that is it failed to demonstrate

5. Thompson, H. L.: Acute Perforation of Peptic Ulcer. An Experimental and Diagnostic Study, and Series. California West Med 41:116, 1915.

free air in 34 per cent of the cases. In the group of resections roentgenologic examination was of diagnostic value in 80 per cent of the cases. It was useful in demonstrating obstruction in 32 per cent, penetration in 8 per cent and marginal ulcer in 2 per cent of the cases. On the contrary, it was erroneous and therefore not of diagnostic value in 8 per cent of the cases in this group. In this 8 per cent a roentgenologic diagnosis of carcinoma of the stomach was proved at operation to be erroneous.

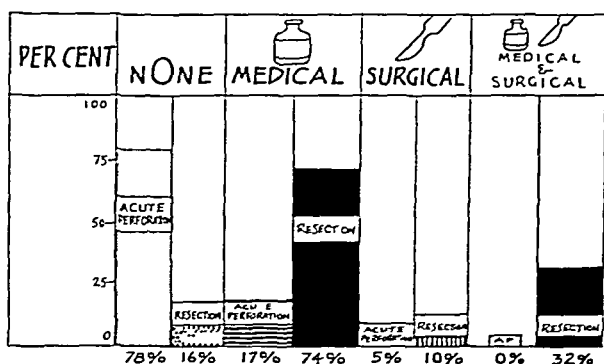


Chart 4—Previous treatment of peptic ulcer treated surgically

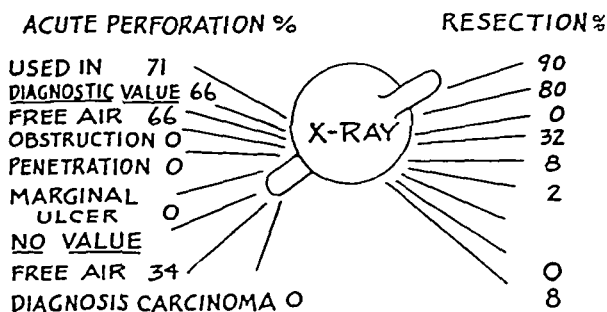


Chart 5—Diagnosis of peptic ulcer for which operation was performed

TREATMENT

Surgeon—Except from certain teaching hospitals the rating of the surgeon is given in relatively few reports in the literature. McKittrick and associates⁶ reported that in the two stage pyloric resection for duodenal ulcer as recently carried out at Massachusetts General Hospital the first stage of the operation was performed by the senior surgeon in 46 per cent, the junior in 32 per cent and the resident in 21 per cent.

6 McKittrick L. F. Moore F. D. and Warren R. Complications and Mortality in Subtotal Gastrectomy for Duodenal Ulcer. *Trans. S. A.* 62: 531-561 1944


of cases In the present study it was found that operations were performed by nineteen surgeons in the group of acute perforations, an average of more than 5 cases each Operations were performed by twenty surgeons in the group of resections or an average of less than 2 each In the group of acute perforations senior surgeons did not perform any of the operations (table 6) Junior surgeons performed

TABLE 6—*Surgeons Performing Surgical Treatment of Peptic Ulcer*

Surgeon	Acute Perforation %	Resection and Other Procedure %
Senior	0	30
Junior	8	22
Resident	92	48

8 per cent and resident surgeons 92 per cent In the group of resections on the other hand, senior surgeons performed 30 per cent, junior surgeons 22 per cent and resident surgeons 48 per cent of the operations

Anesthesia—Anesthesia is discussed in the literature usually in connection with mortality Thus DeBakey³ found the lowest mortality



SURGEON	ACUTE PERFORATION %	RESECTION %
SENIOR	0	30
JUNIOR	8	22
RESIDENT	92	48

Chart 6—Treatment of peptic ulcer for which operation was performed.

rate when spinal anesthesia was used and the highest when local was employed In this series of acute perforations (table 7) inhalation (ether or cyclopropane) anesthesia alone was used in 13 per cent, spinal alone in 53 per cent, spinal with supplemental anesthesia in 33 per cent

TABLE 7—*Anesthesia Used in Surgical Treatment of Peptic Ulcer*

Anesthesia	Acute Perforation %	Resection and Other Procedure %
Inhalation (ether cyclopropane)	13	14
"	53	17
"	33	4
"	1	0

and pentothal sodium alone in 1 per cent of the cases In the group of resections the relationship is somewhat different Inhalation anesthesia alone was used in 14 per cent, spinal alone in 12 per cent and spinal with supplemental anesthesia in 74 per cent of cases

Postoperative Treatment—Recent improvements in postoperative treatment are of the greatest practical importance. Apparently, however, they have not reduced mortality as much as could be desired. In the group of acute perforations (table 8) Levin suction was used in 100 per cent of cases, chemotherapy in 91 per cent, transfusions of

TABLE 8—*Postoperative Treatment of Peptic Ulcer Surgically Treated*

	Acute Perforation %	Resections and Other Procedures %
Levin suction	100	96
Inhalation oxygen-carbon dioxide		80
Theophylline ethylenediamine		66
Chemotherapy	91	48
Transfusion of blood	92	46
Penicillin	14	6

blood in 52 per cent and penicillin in 14 per cent of the cases. In the group of resections, Levin suction was used in 96 per cent, inhalations of oxygen-carbon dioxide in 80 per cent, prophylactic theophylline ethylenediamine in 66 per cent, chemotherapy in 48 per cent, transfusions of blood in 46 per cent and penicillin in 6 per cent of cases.

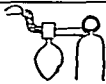


ANESTHESIA	ACUTE PERFORATION	RESECTION
		
INHALATION (ether cyclopropane)	13 %	14 %
SPINAL	53 %	12 %
SPINAL WITH SUPPLEMENTAL	33 %	74 %
PENTOTHAL ONLY	1 %	0 %

Chart 7—Treatment of peptic ulcer treated surgically

RESULTS OF SURGICAL TREATMENT

Complications—It is well known that the commonest complications in gastric surgical treatment are pulmonary diseases, peritonitis and infection of the wound with or without separation of the wound. Usually they are discussed with reference to mortality. In the present group of acute perforations pulmonary complications occurred in 6 per cent of the cases (table 9) general peritonitis in 10 per cent localized peritonitis in 10 per cent infection of the wound in 34 per cent and separation of the wound in 1 per cent. In the group of resections pulmonary complications occurred in 20 per cent general peritonitis in 14

per cent, localized peritonitis in 2 per cent, infection of the wound in 10 per cent and separation of the wound in 10 per cent of the cases

Mortality—The over-all mortality rate in this group of 150 cases was 19.33 per cent. In the group of acute perforations (table 10) there were 15 deaths. In the group of resections there were 14 deaths.

TABLE 9—Complications of Peptic Ulcer Requiring Surgical Treatment

Type	Acute Perforation %	Resections and Other Procedures %
Pulmonary		
Peritonitis	6	20
General	10	14
Localized	10	2
Wound		
Infection	34	10
Separation	1	10

TABLE 10—Mortality Rate in Peptic Ulcer Requiring Surgical Treatment

	Acute Perforation No.	Re section No.
Deaths	15	14

ACUTE PERFORATION

Prognosis—It long has been known that in acute perforation of peptic ulcer one of the most significant factors in prognosis is the interval of time which elapses between perforation and operation. In 7,683

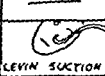

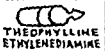

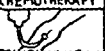
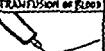
ACUTE PERFORATION %		RESECTION %
100		96
—		80
—		66
91		48
52		46
14		6

Chart 8—Postoperative treatment of peptic ulcer treated surgically

cases collected from the literature by DeBakey,³ the mortality rate in the first six hour period was 10.5 per cent, in the second six hour period 21.4 per cent, in the third six hour period 38.5 per cent, in the fourth six hour period 62.4 per cent and after twenty-four hours 61.5

per cent In the series reported by Black and Blackford,⁷ the mortality rate was 11 per cent within the first six hours, 7 per cent in the second six hours and 25 per cent when operation was performed after twelve hours In our present series (table 11) the mortality rate when operation was performed within the first six hours was 4.7 per cent, between






TYPE	ACUTE PERFORATION %	RESECTION %
 PULMONARY	6	20
 GENERAL PERITONITIS	10	14
 LOCALIZED PERITONITIS	10	2
 INFECTION WOUND	34	10
 SEPARATION WOUND	1	10

Chart 9—Complications in peptic ulcer for which operation was performed

six and twelve hours 9 per cent, between twelve and eighteen hours 25 per cent, between eighteen and twenty-four hours 50 per cent and after twenty-four hours 66.6 per cent

Operative Procedure—One of the most controversial aspects of the treatment of acute perforation of peptic ulcer is the type of operative procedure While continental European surgeons favor radical resection, American and English writers prefer simple closure of the perforation or a modification thereof Drainage of the peritoneal cavity, once

TABLE 11—*Prognosis in Acute Perforation of Peptic Ulcer*

Postoperative Interval Hours	Mortality	
	No	%
6	21	4.7
12	53	9.0
18	16	25.0
24	2	30.0
24+	6	66.6

a point of controversy, now seems to have been abandoned generally Recently a good deal of attention has been paid to the type of incision and method of closure of wounds Black and Blackford⁷ have advocated a combination of layer closure with surgical gut reinforced by through and through nonabsorbable sutures In this present study, simple suture

⁷ Black B M and Blackford R E. Perforated Peptic Ulcer. Review of Ninety-Six Cases. S Clin North America 25:918-923 (Aug) 1945

of the perforation was carried out in 7 cases (table 12), with a mortality rate of 14 per cent. Suture of the perforation reenforced with a tag of omentum was employed in 93 cases, with a mortality rate of 15 per cent. Drainage of the peritoneal cavity was employed in only 4 cases, with a mortality rate of 25 per cent. Layer closure of the wound with surgical gut, cotton or steel wire was utilized in 71 per cent of cases, with a mortality rate of 9.8 per cent. Through and through closure of the wound with wire, cotton or silk was utilized in 29 cases, with a mortality,

TABLE 12—Results of Treatment of Acute Perforation in Peptic Ulcer

Procedure	Cases	Deaths	Mortality Rate %
Simple suture	7	1	14.0
Suture and tag of omentum	93	14	15.0
Drainage of peritoneal cavity	4	1	25.0
Layer closure (surgical gut cotton or wire)	71	—	9.8
Through and through closure (wire cotton or silk)	29	8	27.5

rate of 27.5 per cent. Thus the lowest mortality rate obtained in cases in which simple closure without drainage of the peritoneal cavity and layer closure were employed. Beyond question, however, other factors come into play here.

Factors in Mortality Rate in Acute Perforation—Age. In DeBakey's³ collected series of 4,147 cases, the mortality rate in the

ACUTE PERFORATION
15 DEATHS

RESECTION
14 DEATHS



Chart 10—Mortality rate in peptic ulcer treated surgically

first three decades was 12.5 per cent, in the fourth and fifth decades 23 per cent, in the sixth and seventh decades 47.2 per cent and in the eighth decade 53.8 per cent. Our results in this respect, contained in table 13, disclose an extremely low mortality rate of 4 per cent in the fourth decade, a mortality rate of 20.6 and 20.8 per cent in the fifth and sixth decades respectively, a falling off of mortality rate to 16.6 per cent in the seventh decade and a sharp rise to a high of 28.5 per cent in the eighth decade.

Surgeon. In this group (table 13) the mortality rate according to the staff rating of the surgeon is of interest. In 8 cases in which opera-

tion for acute perforation was performed by junior surgeons, the mortality rate was 37.0 per cent. In 92 cases in which operation was performed by resident surgeons, the mortality rate was 12 per cent. While the junior attending surgeons assumed the responsibility for surgical treatment in 1 of the patients presenting a high risk, the mortality in the other 2 patients, aged 44 years, whose interval between

TABLE 13—*Factors in Mortality in Acute Perforation in Peptic Ulcer*

Factor	Cases	Deaths	Per Cent
Decades			
4th	25	1	4.0
5th	29	6	20.6
6th	24	5	20.8
7th	6	1	16.6
8th	7	2	28.5
Interval			
6 hr	21	1	4.7
12 hr	35	5	14.3
18 hr	16	4	25.0
24 hr	2	1	50.0
24— hr	6	4	66.6
Surgeon			
Junior	5	3	60.0
Resident	92	12	13.0

perforation and operation was ten hours or less, resulted from general peritonitis and bronchopneumonia or both.

Anesthesia DeBakey,³ in 1,776 collected cases, found that with general anesthesia the mortality rate was 29.9 per cent, with spinal anesthesia 17.0 per cent and with local anesthesia 52.8 per cent. In the present study (table 14) inhalation anesthesia used alone was

TABLE 14—*Factors in Mortality in Acute Perforation of Peptic Ulcer*

Factor	Cases	Death	Per Cent
Anesthesia			
Inhalation only	13	3	23.0
Spinal only	23	3	13.2
Spinal with supplemental	25	4	16.1
Pentothal sodium	1	1	100.0
Complication			
Peritonitis			
General	10	9	90.0
Localized	10	3	33.3
Pulmonary	6	1	16.6
Hepatitis	1	1	100.0
Reperforation	1	1	100.0

attended by a mortality rate of 23.0 per cent, spinal anesthesia given alone by 13.2 per cent, spinal with supplemental anesthesia by 16.1 per cent and pentothal sodium administered alone by 100 per cent mortality. These figures strongly favor the use of spinal anesthesia with supplemental measures.

Complications The mortality rate according to complications in this series (table 14) is of interest. In 10 cases of general peritonitis the mortality rate was 90 per cent and in 10 cases of localized peritonitis

it was 33.3 per cent. In 6 patients in whom pulmonary complications followed operation, the mortality rate was 16.6 per cent. In 1 case of

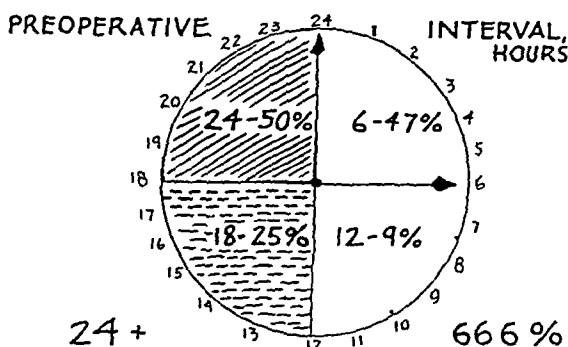


Chart 11—Acute perforation in peptic ulcer

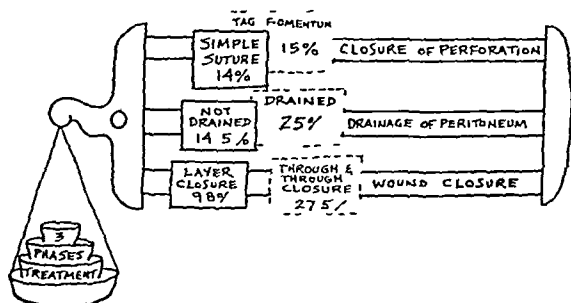


Chart 12—Results of treatment of acute perforation of peptic ulcer

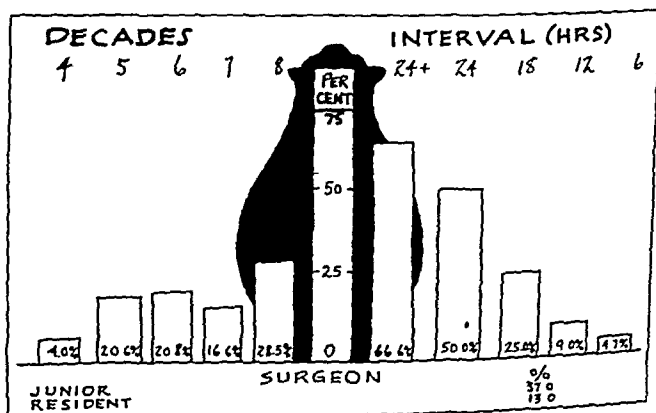


Chart 13—Factors in mortality in acute perforation of peptic ulcer

hepatitis and 1 case of reoperation of ulcer the mortality rate in each was 100 per cent

PEPTIC ULCER TREATED BY RESECTION AND
OTHER SURGICAL PROCEDURES

Clinical Data—Duration in Years The chronicity of peptic ulcer up to the time the patient submits to surgical treatment is indicated by the duration of symptoms in years. In this group (table 15) the patients gave a typical history of ulcer up to one year's duration in 24 per cent, of one to ten years in 36 per cent, of eleven to twenty years in 30 per cent and of twenty-one to fifty years in 10 per cent. In 76 per cent of the patients in this group, therefore, the history of ulcer was given in terms of years rather than weeks or months.

TABLE 15—*Clinical Data on Resections and Other Procedures for Peptic Ulcer*

Duration Yr	Per Cent
0 to 1	24
1 to 10	36
11 to 20	30
21 to 50	10

Major Symptoms Of clinical interest is the analysis of major symptoms in patients undergoing radical surgical treatment for chronic peptic ulcer. Pain was the major symptom in 80 per cent (table 16), bleeding in 62 per cent and vomiting in 54 per cent of the cases. These symptoms existed singly in only 18 per cent of the cases, whereas all three existed in 12 per cent of the cases. In other words, two or more major symptoms coexisted in 82 per cent of the cases. For example, multiple hemorrhages (from two to six) had occurred previously to operation in 6 per cent of cases.

TABLE 16—*Clinical Data on Resections and Other Procedures for Peptic Ulcer*

Major Symptoms	Per Cent
Pain	80
Bleeding	62
Vomiting	54
Only one	18
All three	12
Multiple hemorrhages (2 to 6)	6

Results of Radical Treatment—Concerning gastric resection or other radical surgical treatment of peptic ulcer, Counseller⁸ stated that whereas in 1928 at the Mayo Clinic nearly 40 per cent of patients with duodenal ulcer were treated surgically, now less than 15 per cent are subjected to operation. Hinton⁹ reported that in his clinics over a fourteen year

⁸ Counseller A. S. *Surgery of the Stomach and Duodenum*. S. Clin. North America 25:891-902, 1945.

⁹ Hinton J. W. *Surgical Treatment of Chronic Duodenal Ulcer*. Bull. New York Acad. Med. 22:227-236, 1946.

period operation was advised for duodenal ulcer in only 14 per cent of the cases. McKittrick and his co-workers,⁶ on the other hand reporting from the Massachusetts General Hospital, stated that during 1936 and 1941 there were fifty-five subtotal resections performed for gastric ulcer and one hundred and twenty-four resections for duodenal

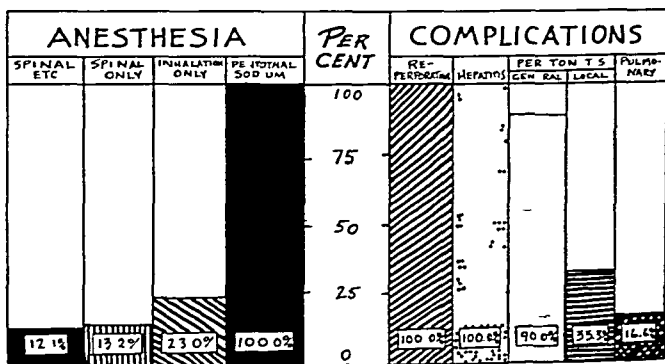


Chart 14—Factors in mortality in acute perforation of peptic ulcer

ulcer. Our study (table 3) revealed that resection or other radical procedure was carried out for duodenal ulcer in 66 per cent, for gastric ulcer in 32 per cent and for marginal ulcer in 2 per cent of the cases.

Operative Procedure. Of major interest in our group in which radical operation was performed is the type of surgical procedure carried out. Partial gastric resection was employed in 82 per cent of the cases. Of

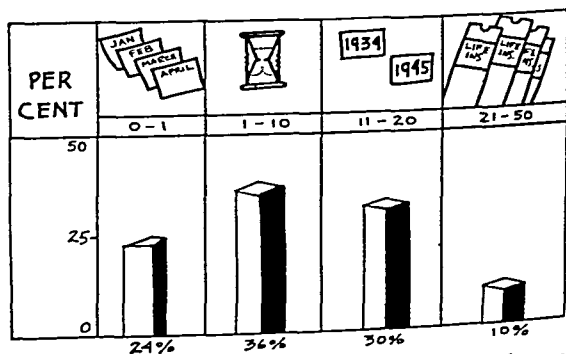


Chart 15—Clinical data on resections and other procedures for peptic ulcer

these resections, the antecolic Polya type was performed in 27 cases (table 17), with a mortality rate of 22.2 per cent. The posterior Polya type was used in 8 cases, with a mortality rate of 12.5 per cent. Hottelmeister anastomosis was utilized in 5 cases, with a mortality rate of 80 per cent and the Billroth II procedure in 1 case, without mortality. Of

the anastomoses, gastrojejunostomy was used in 6 cases, with a mortality rate of 50 per cent. Gastroduodenostomy was employed in 1 case, without mortality. An unusual feature in this group of cases is the fact that total gastrectomy was performed in 2 cases, presumably for carcinoma, without mortality. In 1 of these cases there was found at operation diffuse induration of the gastric wall suggestive of carcinoma. In the other there were multiple indurated lesions, one at the pyloric

TABLE 17—*Results of Treatment of Resections and Other Procedures for Peptic Ulcer*

Procedure	Cases	Deaths	Mortality %
Resections			
Antecolic Polya	27	6	22.2
Posterior Polya	8	1	12.5
Hofmeister	5	4	80.0
Billroth II	1	0	0.0
Anastomoses			
Gastrojejunostomy	6	3	50.0
Gastroduodenostomy	1	0	0.0
Total gastrectomy	2	0	0.0

end and another at the cardiac end of the stomach. Pathologic examination of the lesions in these 2 cases proved them to be benign ulcers without evidence of malignancy.

Factors in Mortality—Major Symptoms. The major symptoms or indications for which resection or other elective operation was performed, along with their relation to mortality, are contained in table 18. The indication was intractable pain in 40 cases, with a mortality rate of 30 per cent. It was obstruction in 27 cases, with a mortality rate of 37 per cent. A history of bleeding, in most instances combined with other indications, was present in 31 cases, with a mortality rate of 25.8 per cent. Acute perforation was present in 1 case, with a mortality rate of 100 per cent.

TABLE 18—*Factors in Mortality in Resections and Other Procedures for Peptic Ulcer*

Major Symptoms	Cases	Deaths	Per Cent
Pain	40	12	30.0
Obstruction	27	10	37.0
Bleeding	31	8	25.8
Acute perforation	1	1	100.0

Age. Recently attention in the literature has been given to the variations in mortality rate according to the ages of the patients. The age-mortality relationship in our series is shown in table 19. In the fifth decade there were 14 patients, with a mortality rate of 21.4 per cent. In the sixth decade 15 patients underwent radical operation with a mortality rate of 26.1 per cent. There were 12 patients in the seventh decade with a mortality rate of 58.3 per cent.

Duration With relation to duration of symptoms, mortality is indicated in table 19. There were 12 patients in whom the duration of symptoms of peptic ulcer was one year or less, with a mortality rate of 16.6 per cent. There were 18 patients in whom the duration was one to ten years, with the same percentage of mortality. In 15 patients symptoms of peptic ulcer had existed for eleven to twenty years, with

TABLE 19—*Factors in Mortality in Resections and Other Procedures for Peptic Ulcer*

Factor	Cases	Deaths	Per Cent
Decades			
5th	14	3	21.4
6th	15	4	26.7
7th	12	7	58.3
Duration			
0 to 1 yr	12	2	16.6
1 to 10 yr	18	3	16.6
11 to 20 yr	15	5	33.3
21 to 50 yr	5	4	80.0
Surgeons			
Senior	15	2	13.3
Junior	11	7	63.6
Resident	24	5	20.8

a mortality rate of 33.3 per cent. In 5 patients the duration was twenty to fifty years, with a mortality rate of 80 per cent. These figures indicate that the shorter the duration, and therefore the younger the patient, the lower the mortality rate.

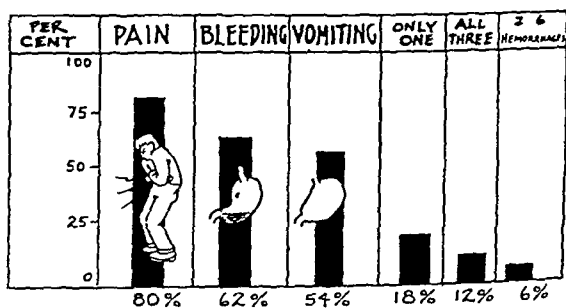


Chart 16—Clinical data on resections and other procedures for peptic ulcer

Surgeon The mortality rate according to the staff rating of the surgeon is illustrated in table 19. Senior staff surgeons operated on 15 patients, with a mortality rate of 13.3 per cent. Junior staff surgeons operated on 11 patients, with a mortality rate of 63.6 per cent. Resident house surgeons operated on 24 patients, with a mortality rate of 20.8 per cent. While it is clear that the resident surgeons were assigned the cases with the least operative risk, it is difficult to explain why the

mortality rate in the patients operated on by the junior surgeons should be so high

Preexisting Associated Pathologic Changes In an attempt to determine causes of a high mortality rate in some groups a search was made for preexisting pathologic changes. In the fatal cases, preexisting patho-

TABLE 20—*Factors in Mortality in Resections and Other Procedures for Peptic Ulcer*

Factors	Cases	Deaths	Per Cent
Preexisting associated pathologic change			
Syphilis	—	2	42.8
Diabetes	1	1	100.0
Carcinoma (larynx)	1	1	100.0
Localized peritonitis	1	1	100.0
Surgical (technic)			
Duodenal blowout	6	5	83.3
Wound separation	5	2	40.0
Bile peritonitis	1	1	100.0
Vicious cycle	1	1	100.0
Shock	1	1	100.0
Surgical (beyond control of operator)			
Pulmonary	10	2	20.0
Thrombophlebitis	3	1	33.3
Embolism	2	2	100.0
Malnutrition	2	1	50.0
Mesenteric thrombosis	1	1	100.0
Cerebral accident	1	1	100.0
Parotitis	1	1	100.0

logic changes appeared to be at least partially responsible for the high mortality rate, as shown in table 20. Positive serologic reactions were present in 7 cases, having a mortality rate of 42.8 per cent. Diabetes, carcinoma of the larynx and localized omental abscesses discovered at

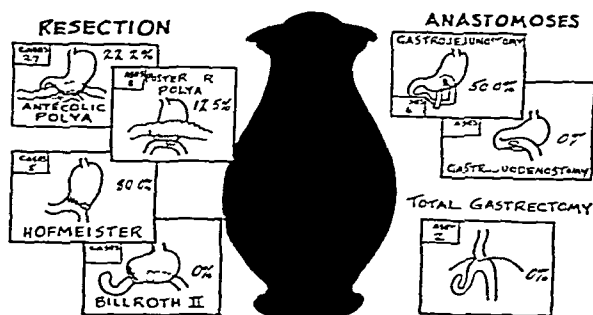


Chart 17—Results of treatment in resections of peptic ulcer

operation each were present in 1 case, with a mortality rate of 100 per cent. These findings indicate that candidates for radical surgical treatment should be scrutinized closely for associated pathologic changes.

Surgical Technic Mortality as it appeared to be related to surgical technic, therefore under control of the operator, is illustrated in table 20.

As McKittrick and colleagues⁶ have pointed out, it is well known that duodenal blow out is the commonest cause of death in partial gastrectomy for duodenal ulcer. Duodenal blowout occurred in 6 cases in this series, with a mortality rate of 83.3 per cent. In 4 of these cases duodenal ulcers were dissected with difficulty off the head of the pancreas. In the fifth case, dissection was not attempted but note was made of extreme

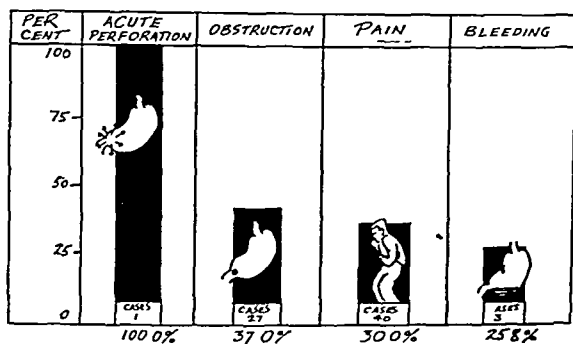


Chart 18—Factors in mortality in resection of peptic ulcer

edema of the first portion of the duodenum and a drain was inserted in anticipation of possible blowout. The sixth case was one of a gastric ulcer penetrating into the body of the pancreas. The ulcer and the duodenum were dissected off the pancreas.

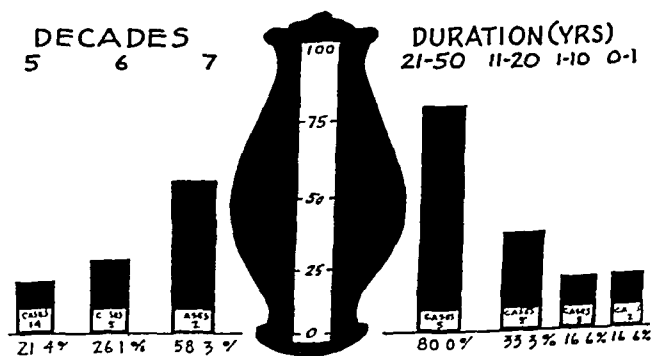


Chart 19—Factors in mortality in resections and other procedures for peptic ulcer

The importance of continuous decompression of the stomach after resection now is generally accepted. In only 2 of these cases was special nursing available to insure uninterrupted suction through the nasal tube.

Separation of the wound complicated convalescence in 5 cases, with a mortality rate of 40 per cent. Bile peritonitis, vicious cycle and shock

each complicated 1 case, with 3 deaths, or a mortality of 100 per cent. The first of these attended attempt to excise a penetrating duodenal ulcer.

Surgical Mortality Beyond the Control of the Operator. Surgical mortality attributable to factors beyond the control of the operator is illustrated in table 20. Pulmonary complications occurred in 10 cases with a mortality rate of 20 per cent. Deep thrombophlebitis occurred in 3 cases with a mortality rate of 33.3 per cent. Embolism occurred in 2

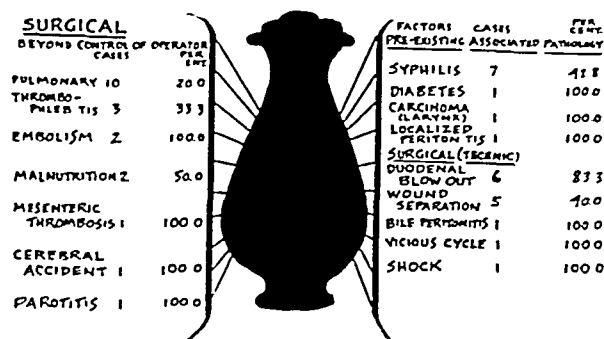


Chart 20—Factors in mortality in resections and other procedures for peptic ulcer.

cases, with a mortality rate of 100 per cent. Malnutrition supervened in 2 patients, with a mortality rate of 50 per cent. Mesenteric thrombosis, cerebral accident and parotitis each occurred in 1 case, with fatal results, or a mortality rate of 100 per cent. These complications, therefore, account for mortality rate in 18 per cent of cases.

TABLE 21—*Factors in Mortality in Resections and Other Procedures for Peptic Ulcer*

Factor	Cases	Deaths	Per Cent
Anesthesia			
Inhalation only	7	5	71.4
Spinal only	6	5	83.3
Spinal with supplemental	37	4	10.8
Site and type of ulcer			
Multiple	5	5	100.0
Simple	6	0	59.0
Obstruction	11	0	18.1
Penetration	13	0	15.3
Bleeding	2	1	50.0
Acute perforation	1	1	100.0

Anesthesia. The relation of anesthesia to mortality rate in this series is illustrated in table 21. Inhalation anesthesia alone was used in 7 cases, with a mortality rate of 71.4 per cent. Spinal anesthesia alone was used in 6 cases, with 5 deaths, or a mortality rate of 83.3 per cent. Spinal with supplemental anesthesia was used in 37 cases, with 4 deaths or a mortality rate of 10.8 per cent.

Site and Type of Ulcer The site and type of ulcer frequently are factors in mortality. As indicated previously, this is true especially if an attempt is made to excise a duodenal ulcer which penetrates into the head of the pancreas. For this reason, Reinhoff¹⁰ has abandoned surgical removal, and McKittrick and associates⁶ have developed the two stage resection procedure. As illustrated in table 21, multiple ulcers occurred in 5 cases in our series, with 5 deaths, or a mortality rate of 100 per cent. Only in 6 cases did simple, uncomplicated ulcer occur. In this group, however, there were 3 deaths, or a mortality rate of 50 per cent. Obstruction complicated ulcer in 11 cases, with 2 deaths, or a mortality rate of 18.1 per cent. Penetration into adjacent viscera was demonstrated in 13 cases, with 2 deaths, or a mortality rate of 15.3 per cent. Bleeding was a factor in 2 cases, with 1 death, or a mortality

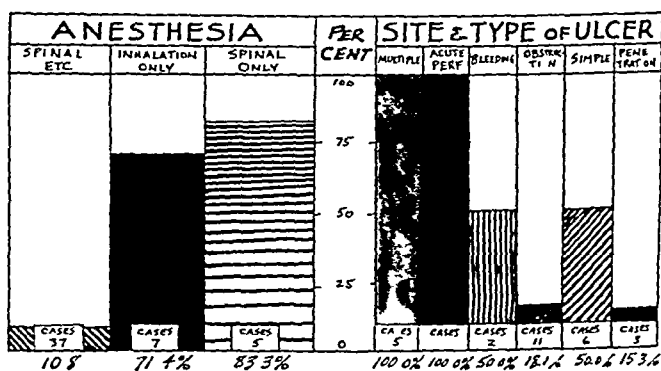


Chart 21—Factors in mortality in resection of peptic ulcer

rate of 50 per cent. Acute perforation was present in 1 case with death, or a mortality rate of 100 per cent. Except for acute perforation and bleeding, known to be the most serious complications of peptic ulcer, the highest mortality rate occurred in simple, uncomplicated ulcers. The reason for this is not discernible in this study.

COMMENT

As has been pointed out, the period during which these observations were made corresponded to the time when the national war effort was at its peak. With high national employment, charity hospital census was low and made up of aged, disabled or otherwise handicapped persons. In addition, the medical and nursing staffs of public hospitals were greatly depleted. Beyond question, the results of this study reflect the

¹⁰ Reinhoff W F. An Analysis of the Results of the Surgical Treatment of Two Hundred and Sixty Consecutive Cases of Chronic Peptic Ulcer of the Duodenum. *Ann Surg* 121:583-599, 1945.

inroads on the efficiency of charity hospitals service that inevitably resulted from the war

It is noteworthy that during the period under observation only 22 per cent of patients with peptic ulcer were treated surgically. This fact is more significant when it is noted that the figure includes the cases of acute perforation. This complication always has accounted for the highest number of surgically treated patients with ulcer in the Los Angeles General Hospital. In view of these figures the surgical staff is not selecting too great a proportion of patients for surgical treatment.

With reference to the age at which radical surgical treatment becomes necessary, it is our strong belief that all patients with ulcers should be treated according to a definite and vigorous medical or surgical program. It is only in this way that proper selection of cases can be made for either continuation of medical treatment or application of surgical treatment. If medical treatment is a matter of indifference to a physician or a patient, the ulcer is allowed to persist until too frequently complications ensue. The good results from operation in such circumstances become correspondingly less. An analogy to this exists in the manner of treating disease of the bile tract, particularly disease of the gallbladder. This is in our opinion, one of the greatest lessons to be learned from studies of this type on patients of charity hospitals.

Whereas at the time Toland and Thompson reported on acute perforation of gastrojejunal ulcer we were able to collect only 103 cases from the literature and elsewhere, so many cases have come to our attention since then as to give one the impression that they are almost commonplace.

It is our belief that the absence of a record of previous treatment in the group of acute perforations is due to the emergency nature of the condition and the fact that frequently the patient is in such poor physical condition as to make the taking of a prolonged past history unwarranted.

Whereas a generation ago the criteria for the diagnosis of peptic ulcer were not well established, the diagnosis now is made readily, with certain exceptions. For confirmation of the clinical diagnosis, the roentgenologic examination now is an adjunct of the utmost value. This is true notwithstanding the fact that at times the roentgenologists' interpretations are misleading. Whereas in this series there was a diagnostic error of 8 per cent, the roentgenogram in most cases did lend material aid in localization of the lesion.

The large number of staff members active in the operative treatment of the cases herein reported suggests that the experience and interest in gastric surgical treatment of at least some of the surgeons are occasional, if not casual. An additional factor in support of this is the fact that there were more resections in duodenal than in gastric ulcers. By many writers this is thought to be too wide employment of radical operation.

in duodenal ulcer. A review of the causes of death in resections performed by junior surgeons does not support the assumption that they assumed responsibility for operation wherein the risk was great. On the other hand, the great proportion of mortality in patients operated on by them seems to have resulted from conditions beyond the control of the surgeon.

With respect to the selection of patients for operation, there are several features which seem to merit discussion. When the existence of a multiplicity of symptoms in the majority of cases is considered, there can be no criticism. However, the question arises regarding the application of radical operation in 6 simple or uncomplicated cases. While this in itself does not necessarily warrant censure, the resulting mortality rate of 50 per cent offers possibilities for thoughtful self criticism. From the standpoint of associated pathologic change, the mortality rate suggests that more emphasis must be placed on the determination of its presence or absence when patients are selected for operation. With respect to the decision as to whether or not to dissect out penetrating duodenal ulcers, references in the literature can be found to support either point of view.

An over-all mortality rate of 19.3 per cent does not appear too bad in light of mortality figures of the past. The fact is that in the series reported by one of us from this hospital less than ten years ago the mortality rate in surgical treatment of acute perforation alone was 28.7 per cent.

The duration of symptoms of peptic ulcer of less than ten years in 60 per cent of the cases of resection indicates that radical operation was not postponed too long in a majority of the cases. However, the fact that in 40 per cent of the cases symptoms existed for periods of eleven to fifty years distinctly emphasizes the lack of a definite program of treatment in this group of patients. Lower mortality rates in younger persons are further evidence of the fact that the program of treatment should be established early so that should operation become necessary it can be applied before the risk increases as a result of advancing years.

The application of gastric resection, partial or total, in 86 per cent of the cases illustrates the trend toward radical operation in the treatment of peptic ulcer. Admittedly less effectual procedures such as gastrojejunostomy and gastroduodenostomy were, moreover, accompanied with higher mortality figures being 25.5 per cent and 42.8 per cent respectively.

In the group of simple ulcers wherein the mortality rate was 50 per cent (incidentally the highest mortality rate except for the bleeding and acute perforations) there were two duodenal ulcers and one gastric ulcer. In one of the duodenal ulcers complicating factors existed

namely, positive serologic reactions and pneumonia. The other was complicated by duodenal blowout. The patient with gastric ulcer died of postoperative shock.

Finally, with respect to mortality in general, if we were to subtract the unavoidable mortality which appeared to be beyond the control of the surgeon and amounting to 18 per cent, the total mortality rate would be only 10 per cent. This figure possibly is not too high if we take into account the working conditions in this group of patients. On the other hand, it is too high according to the criteria that McKittrick and his co-workers laid down. An overlapping of the numerous factors in mortality is readily recognized.

To sum up, this study finally reviews the results in a limited field of altruistic human endeavor. It was applied in civilian life during war-time conditions not only when the type of patient entering the typical charity hospital was influenced but when there was a period of radical curtailment of the surgical and nursing services.

LIVING FASCIAL SUTURES IN INGUINAL HERNIORRHAPHY

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EFFECTIVE closure of the inguinal defect in the presence of hernia presents a problem which has taxed the ingenuity of surgeons for many years. It is the purpose of this communication to present a technic for herniorrhaphy which includes, among other important details, a broad approximation of the internal oblique muscle to the inguinal ligament by a combination of nonabsorbable and living fascial sutures, the latter from the external oblique aponeurosis. Approximation may be secured lateral as well as medial to the internal inguinal ring, and it is believed that the broad scar so formed presents a firm and relatively nonstretchable barrier to recurrence. A series of two hundred and one hernias treated by this method is presented, with a recurrence rate of 1.74 per cent.

ANATOMY AND PHYSIOLOGY OF THE INGUINAL REGION

A clear understanding of the anatomy and physiology of the inguinal region is a fundamental requirement for the intelligent treatment of hernia. These subjects have been recently reviewed by Anson and McVay,¹ to whose beautifully illustrated papers the reader is referred.

The internal inguinal ring is a funnel-shaped defect in the posterior fascial covering of the inguinal region through which the spermatic cord begins its course from the retroperitoneal tissues through the layers of the anterior part of the abdominal wall. This fascia is continued on to the surface of the cord as the internal spermatic fascia.

Except for the peritoneum, the transversalis fascia is the only structure making up the posterior wall of the inguinal canal, and its repair therefore presents the first important barrier to recurrence of the hernia. While there is some difference of opinion as to the exact origin of this layer, it is believed to be the aponeurotic extension of either the transversus abdominis muscle or its fascial coverings. The muscle itself seldom extends sufficiently far caudad to be of practical importance in the surgical repair of the inguinal region.^{1a}

From the surgical services of the Framingham Union Hospital.

1. Anson, B. J., and McVay, C. B. (a) The Anatomy of the Inguinal and Hypogastric Regions of the Abdominal Wall. *Anat. Rec.* 70: 211-225, 1938, (b) Inguinal Hernia. I. The Anatomy of the Region. *Surg., Gynec. & Obst.* 66: 186-191, 1938.

The internal oblique muscle has an important sphincter-like action around the cord at the internal ring.² Its inferior fibers take origin from the pectineal fascia deep to the inguinal ligament, over an area extending from the anterior superior iliac spine to a point somewhat below the internal ring. The fibers arising below the internal ring loop around the cord and, together with those taking origin more laterally, sweep downward and medially to insert in either of two ways. The first, and commoner, type of insertion is into the linea alba, pubic crest and pubic tubercle. Muscle fibers thus surround the internal ring on three sides and when the abdominal muscles are contracted tighten around the cord to reinforce this region. Zimmerman^{2c} pointed out that the effectiveness of this barrier is well illustrated by the fact that even in a patient with indirect hernia, in whom the sac is present from birth, the hernia usually does not manifest itself by filling of the sac until adult life has been reached.

When the internal oblique muscle inserts as described, the medial or lower half of the posterior wall of the inguinal region is reinforced by the fibers inserting into the pubic crest and tubercle. The second, and less common, type of insertion is into the side of the rectus sheath a variable distance above the pubic crest. This type of insertion is found chiefly in direct hernias and forms a triangular defect which has been called the 'inguinal triangle'. This is bounded medially by the lateral edge of the rectus sheath, superiorly by the inferior edge of the internal oblique muscle and inferiorly by the inguinal ligament. In 1912 Polya³ showed that in direct hernia the internal oblique muscle often inserted 2 to 3 cm above the bone. Bassini⁴ was evidently cognizant of the importance of closing this defect, for he advised that the first two sutures be applied "close to the pubic bone and embrace also the external edge of the rectus muscle". Andrews and Bissell⁵ measured the distance from the pubic crest to the inferior edge of the insertion of the internal oblique muscle in a series of twenty direct hernias and found the distance to average 5 cm. Anson and McVay, working on anatomic material, found the

2 (a) Andrews E. A Method of Herniotomy Utilizing Only White Fascia. *Ann Surg* **80** 225-237 1924. (b) McVay C B and Anson B J. Aponeurotic and Fascial Continuities in the Abdomen Pelvis and Thigh. *Anat Rec* **76** 213-231, 1940. (c) Zimmerman L M. Essential Problems in the Surgical Treatment of Inguinal Hernias. *Surg Gynec & Obst* **71** 654-663 1940.

3 Polya M. Causes des recidives apres les operations. *Presse med* **20** 419 1912.

4 Bassini E. On The Treatment of Inguinal Hernia. *Arch r klin Chir* **40** 429 1890. translated by C R Robins. *Virginia M Monthly* **63** 279-283 1936.

5 Andrews E and Bissell A D. Direct Hernia. A Record of Surgical Failures. *Surg Gynec & Obst* **58** 753-761 1934.

distance to vary from 0 to 9 cm, while Robins⁶ frequently found it to be "as much as 1½ inches"

The insertion of the internal oblique muscle into the side of the rectus sheath is important because not only is the sphincteric action of the internal oblique lessened but the reenforcement which its fibers of insertion otherwise give to the posterior wall is also lost. Since the distance between the internal oblique muscle and the inguinal ligament becomes progressively less as the internal ring is approached, it follows that the chief difficulty in utilizing these structures to close the "inguinal triangle" will be at the medial end. Because most recurrent hernias arise in this portion of the inguinal canal and are therefore direct, it is probable that failure to secure permanent closure of this triangular defect is often responsible for their recurrence.

The term "conjoined tendon" has long been used by surgeons and anatomists to indicate a confluence of the tendinous insertions of the transverse abdominal and internal oblique muscles. Anson and McVay have pointed out that such a union takes place, if at all, at a point medial to the lateral edge of the rectus muscle. The term usually refers to the inferior edge of the internal oblique muscle, which in many persons is partially or wholly muscular. Zimmerman⁷ stated that, since the structure is neither conjoined nor tendinous, "the interests of clarity would be better served if the term 'conjoined tendon' were abandoned." These authors also pointed out that the free lower border of the internal oblique muscle is an artefact produced when the cremaster muscle covering the spermatic cord is freed.

The anterior wall of the inguinal canal is formed by the aponeurosis of the external oblique muscle, the lower portion of which folds posteriorly to form the inguinal ligament. The posterior edge of this ligament is attached to the investing fascia of the thigh⁸ and serves as the caudal mooring in most technics of inguinal herniorrhaphy. In the inguinal region the fibers of the external oblique aponeurosis are parallel to the inguinal ligament. Firmly attached at its medial extremity, this aponeurosis is extremely strong when tested in the direction of its fibers yet its fibers readily separate when pulled at a right angle to their long axis. This fact is so obvious that it is difficult to believe that any operation in which an attempt is made to reenforce the inguinal defect by the

6 Robins, C. R. Direct Inguinal Hernia. Presentation of an Operation for Its Cure, *Ann Surg* **108** 389-409, 1938. Why Inguinal Hernia Recurs, *ibid* **114** 118-128, 1941.

7 Zimmerman, L. M. Inguinal Hernia. II The Surgical Treatment of Direct Inguinal Hernia, *Surg, Gynec & Obst* **66** 192-198, 1938.

8 McVay, C. B., and Anson, B. J. A Fundamental Error in Current Methods of Inguinal Herniorrhaphy, *Surg, Gynec & Obst* **74** 746-759, 1942.

use of a flap of this fascia⁹ could have much to recommend it. On the other hand, because of its strength in the direction of its fibers strips may be advantageously used as fascial sutures.

THE PATHOLOGIC CHANGES OF INGUINAL HERNIA

Although indirect and direct inguinal hernias are entirely different etiologically, they often present practically the same problem from the standpoint of surgical repair. It is therefore, important to have a clear insight into their structural similarities, for not only do the two types frequently coexist, but when recurrence takes place after surgical repair of either type the recurrent hernia is usually direct.

Indirect Hernia—Etiologically indirect hernia results from the filling of a preformed sac present at birth and resulting from incomplete obliteration of the processus vaginalis testis. While herniation of abdominal contents into this sac is not rare during infancy and childhood it most commonly occurs during the third and fourth decades. The fact that the congenitally present sac is often prevented from filling during the physically vigorous years of childhood and adolescence, by the sphincteric action of the internal oblique muscle, has already been commented on. When such hernias do occur in children, the force causing the sac to suddenly open and fill is usually only enough to overcome this sphincteric action, there being little or no damage to the muscle or to the transversalis fascia adjacent to the internal ring. In such instances the sac is the only anatomic defect, and all that is necessary to secure a permanent cure is removal of the sac. Such a procedure is satisfactory in infants and young children, and Iason,¹⁰ among others, has recently reported 100 per cent cures in a large series so treated.

When the force is sufficient to cause pain and local tenderness, particularly if the initial injury is followed by a large hernial mass, there is probably always an associated injury to the transversalis fascia, which is split medially from the internal ring for a varying distance. At the same time there is probably also an associated injury to the fibers of the internal oblique muscle, which surround and protect the internal ring. In hernias which are not promptly treated, the continued filling and emptying of the hernial sac causes increasing damage to the structures about the internal ring. In extremely old hernias of this type, the split in the transversalis fascia may extend along the entire posterior wall of the inguinal canal. In these circumstances the inferior epigastric vessels may be pushed farther and farther medially, so that the hernia remains, technically, an indirect one. This in no way alters the important fact

⁹ Andrews E. Further Experiences with Purely Fascial Herniotomy, *Ann Surg* 88 874-878 1928. Zimmerman.

¹⁰ Iason A. H. Hernia in Infancy and Childhood. *Am J Surg* 68 287-296 1945.

that the posterior wall of the inguinal canal has received severe and permanent damage. More commonly, the deep epigastric vessels remain in their usual location but, because of their elasticity, do not prevent the progressive injury to the transversalis fascia. The enlargement of the internal ring toward the pubic tubercle continues, and, in persons in whom the internal oblique muscle inserts into the side of the rectus sheath, the split transversalis fascia presents an avenue for the protrusion of the peritoneal sac of a direct hernia. The patient then has a combined direct and indirect hernia.

As the internal ring enlarges there is progressive injury to the other structures forming the inguinal canal. Not only is the internal oblique muscle stretched and weakened in the part surrounding the internal ring, but there is also a similar injury to the fibers inserting into the pubic crest, so that the sphincteric action is eventually lost. The protrusion of the enlarging hernial mass stretches and separates the fibers of the aponeurosis of the external oblique muscle. Such separation is frequently seen at operation and casts further doubt on the advisability of using this structure as a flap for the repair of inguinal defects.

Direct Hernia—The development of primary direct hernia is probably influenced by the insertion of the internal oblique muscle into the side of the rectus sheath, which thus affords no reinforcement to the posterior wall of the inguinal canal. The entire force of intra-abdominal pressure is exerted against the transversalis fascia, and, if this is not sufficiently strong to withstand the constant fluctuations of abdominal pressure, its fibers stretch, become attenuated and finally separate to allow the protrusion of a peritoneal sac.

Because the split in the transversalis fascia is usually wide, extending laterally from the edge of the rectus muscle along the posterior wall of the inguinal canal, the peritoneal sac usually has a wide internal opening. If the hernial mass simply pushes forward the anterior wall of the inguinal canal, there is little danger of strangulation. However, as demonstrated in the series of cases to be presented, the direct hernial sac often extends through the subcutaneous inguinal ring, where strangulation not only is possible but is relatively frequent.

THE SURGICAL REPAIR OF INGUINAL HERNIA

Until the last decade of the nineteenth century the results of inguinal herniorrhaphy were universally poor. During that decade the pioneer work of Halstead,¹¹ Bassini⁴ and Ferguson¹² pointed the way to vast

¹¹ Halstead, W. S. The Radical Cure of Hernia, *Bull. Johns Hopkins Hosp.* 12-13, 1889, The Radical Cure of Inguinal Hernia in the Male, *ibid.* 17, 17-24, 1893, The Cure of the More Difficult as Well as the Simple Inguinal Rupture, *ibid.* 14, 208-214, 1903.

superior results. Since then a large amount of literature on the technical aspects of the subject has accumulated. With the exception of the work of McArthur¹³ and Gallie and LeMesurier¹⁴ on the use of autoplasmic fascia, little of fundamental importance has been added. For instance, recent studies¹⁵ comparing the end results of herniorrhaphy using various types of suture material have confirmed the correctness of Halstead's teachings as to the advantages of silk. Similarly, with a few dissenters¹⁶ most recent reports¹⁷ show improved results with the use of fascial sutures as advocated by McArthur or Gallie and LeMesurier. The following technic has been used in the series of cases presented in this paper.

The incision for inguinal herniorrhaphy has received scant attention. Because the medial end of the inguinal canal is the point at which recurrence is most likely to take place, adequate exposure demands an incision which starts near the midline, about 1 cm above the pubic crest. From this point the incision is made parallel to the inguinal ligament and about 2 cm above it, to a point 2 cm medial to the anterior superior iliac spine (fig 1A). Adequate exposure is as important in herniorrhaphy as in any field of surgery.

After the external oblique aponeurosis has been freed of subcutaneous fat over a wide area, it is incised at the medial pillar or the external inguinal ring and split in the direction of its fibers as far as the incision will permit. The internal oblique muscle is then widely exposed by separation of it from the external oblique aponeurosis. The spermatic cord is freed from the inguinal ligament, the cre-

12 Ferguson, A. H. On the Radical Cure of Inguinal and Femoral Hernia by Operation, *Ann Surg* **21** 547-564, 1895

13 McArthur, L. L. Autoplasmic Suture in Hernia and Other Diastases. Preliminary Report, *J A M A* **37** 1162-1165 (Nov 2) 1901, Autoplasmic Sutures in Hernia and Other Diastases. Final Report, *ibid* **43** 1039-1048 (Oct. 8) 1904

14 Gallie, W. E., and LeMesurier, A. B. The Use of Living Sutures in Operative Surgery, *Canad M. A. J.* **11** 504-513, 1921

15 Parsons, W. B. Silk Sutures in the Repair of Hernia, *Ann. Surg* **106** 343-347, 1937. Longacre, A. B. Follow-Up of Hernia Repair, *Surg, Gynec. & Obst* **68** 239-246, 1939

16 Burdick, C. G., Gillespie, D. H. M., and Higginbotham, N. L. Fascial Suture Operations for Hernia. Summary and End Results of 1485 Operations. *Ann Surg* **106** 333-343, 1937. Grace, R. V. and Johnson, V. S. Results of Herniotomy in Patients of More than Fifty Years of Age, *ibid* **106** 347-362, 1937

17 (a) Seelig, M. G., and Chouke, K. S. A Fundamental Factor in the Recurrence of Inguinal Hernia. *Arch Surg* **7** 553-572 (Nov.) 1923. (b) Lyle, H. H. M. Fascial Sutures for Inguinal Hernia, *Ann. Surg* **88** 870-873, 1928. (c) Bisgard, J. D. The Use of Living Sutures of the External Oblique Aponeurosis in the Repair of Inguinal Hernias in Adults. *Surg, Gynec. & Obst* **68** 113-117, 1939. (d) Sachs, L. Autoplasmic Fascia Sutures in Repair of Inguinal Hernia. *ibid* **69** 515-517, 1939. (e) Joyce, T. M. Fascial Repair of Inguinal Hernias. Report of Seven Hundred and Sixty Operations from January 1934 to January 1939, *J A M A* **115** 971-977 (Sept 21) 1940. (f) McCloskey, J. F. and Lehman, J. A. Living Fascial Sutures in the Repair of Large Inguinal Herniae. *Ann Surg* **111** 610-617, 1940. (g) Ryan, W. J. Living Fascial Suture in the Repair of Inguinal Hernia, *Surg, Gynec. & Obst.* **77** 535-538, 1943

master muscle fibers separated from the inferior border of the internal oblique muscle and the cord retracted to expose the posterior wall of the inguinal canal. The important structures at the medial end of the inguinal canal are carefully identified. These include the pubic tubercle, the medial extremity of the inguinal ligament, the lacunar ligament, the rectus muscle and its sheath and, most important, the insertion of the internal oblique muscle, whether it be into the pubic bone or into the side of the rectus sheath.

The hernial sac is then isolated. In indirect hernias this is readily accomplished through a longitudinal incision in the muscular and aponeurotic covering of the cord, care being taken to avoid injury to the ilioinguinal nerve. The sac is opened and, with a finger inside, separated from the other cord structures by gauze dissection. The index finger of one hand is then introduced through the neck of the sac, its width estimated and the posterior wall of the inguinal canal

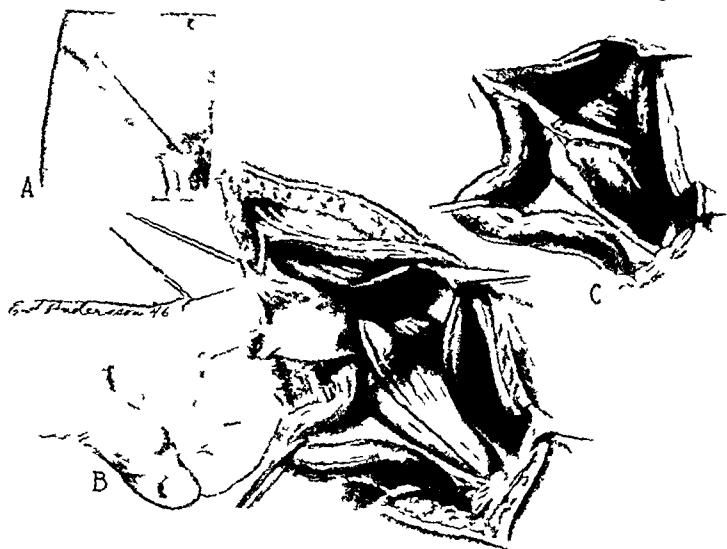


Fig 1—A, incision B, indirect hernia, showing split in transversalis fascia C primary direct hernia

and the region of the femoral ring carefully palpated from within the abdomen to determine whether or not coincidental direct or femoral hernias are present. With the cord retracted laterally to expose the region of the internal ring and with the index finger pushing forward the posterior wall of the inguinal canal from within the abdomen, the transversalis fascia is carefully freed of fat so that its fibers can be clearly identified (fig 1 B). When properly exposed the split that is usually present will be clearly evident. If there is a wide split, the inferior epigastric vessels, which lie between the peritoneum and fascia, will be prominently exposed.

After proper exposure of the transversalis fascia, the hernial sac is transfixed, ligated and amputated at its neck, and the stump is allowed to retract under the lateral fibers of the internal oblique muscle. The defect in the transversalis fascia is then carefully closed with a continuous suture (fig 2 A).

Should a direct hernial sac also be present it is usually not necessary to excise it, since it often is only a bulge through an elongated rent in the trans

transversalis fascia. Narrow peritoneal diverticula occasionally arise from direct hernial sacs,¹⁸ and these should be amputated after the necks have been closed with transfixion ligatures.

In primary direct hernia the sac may or may not be opened depending on its configuration. The diffuse bulge need not be opened (fig 1 C), but the more pedunculated sac, particularly if it extends through the external inguinal ring, should be opened and excised, care being taken to avoid injury to the bladder. Whether or not the sac is excised, the rent in the transversalis fascia should be painstakingly closed from the pubic tubercle to the internal inguinal ring.

In all primary direct hernias it is essential that a careful search be made for a coexisting indirect sac. If the direct sac is opened this search may be quickly made with the exploring finger within the abdomen. If the direct sac is not opened the search should be made by separating the structures of the spermatic cord in its proximal portion near the internal ring so that small sacs may not be overlooked.

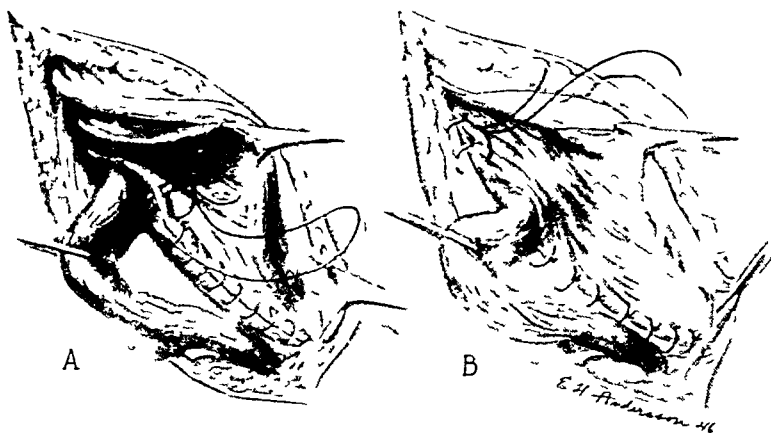


Fig 2—A, closure of the transversalis fascia. B, approximation of the internal oblique muscle to the inguinal ligament with interrupted sutures.

After the transversalis fascia has been closed a reinforcing layer is secured over it by suturing the internal oblique muscle or aponeurosis (if an aponeurotic insertion is present) to the inguinal ligament (fig 2 B). In indirect hernias this is readily accomplished, since the insertion of the muscle into the pubic crest and tubercle leaves only a narrow space between its inferior border and the inguinal ligament. When the internal oblique muscle inserts into the side of the rectus sheath, as in direct hernia, the closure of the "inguinal triangle" is accomplished in the same fashion except that in the medial portion the side of the rectus sheath is approximated to the inguinal ligament from its point of insertion into the pubic bone up to the point at which it is joined by the insertion of the internal oblique muscle. In rare instances this triangular defect is so wide that approximation can be accomplished only with great tension. In these circumstances the tension should be relieved by a vertical incision made through the anterior rectus sheath just lateral to the midline on the same side. Moderate tension is relieved by the fascial suture to be described.

The approximation of the internal oblique muscle (and rectus sheath, when this is necessary) to the inguinal ligament is best done with interrupted 00 silk or nylon sutures. Such relatively large suture material has the advantage of increased strength as well as of lessened danger of cutting. The accurate approximation of these structures is greatly facilitated by the use of an instrument designed to hold knots without cutting or otherwise weakening the suture material. A satisfactory instrument for this purpose has been made from a Crile hemostat, the serrations of which have been filed away and the edges of the jaws rounded off. With such an instrument the first throw of the knot can be tightened so that accurate approximation is secured without strangulation of tissue. The knot is then held firmly, without slipping, while the second throw is completed.

If an aponeurotic insertion of the internal oblique muscle is present it is desirable that this, rather than muscle tissue, be approximated to the inguinal ligament. Often, particularly in indirect hernias, such an aponeurotic layer lies under a sheaf of muscle tissue at the inferior edge of the internal oblique muscle. Removal of this sheaf of muscle tissue will expose the aponeurotic layer.

If no aponeurotic layer of the internal oblique is present, the muscle tissue itself forms a satisfactory layer for approximation to the inguinal ligament. Seelig and Chouke¹⁹ have shown experimentally that muscle and fascia will unite firmly only if there is injury to the muscle tissue. Such injury allows firm union to take place between the fascia and the endomysial, epimysial and perimysial connective tissue of the muscle.¹⁹ Controlled injury to muscle to allow such muscle-fascia union may be satisfactorily accomplished by the use of a reenforcing suture of autogenous fascia. Because of its availability, fascia secured from the external oblique aponeurosis is more desirable than fascia lata.

To develop the reenforcing fascial suture a straight hemostat is applied across 1 cm of the medial edge of the external oblique aponeurosis near the anterior superior iliac spine, where it begins to thicken before surrounding the muscle. The aponeurosis is divided at this point, and a fascial strip 1 cm wide is separated down to its medial attachment, which forms a firm anchorage that is not disturbed. The free end is tied with fine cotton or silk, and this ligature used to thread the fascial strip through a small-curved, large-eyed needle (fig 3).

With the needle firmly affixed, the reenforcing fascial suture is inserted, care being taken not to twist it. In both direct and indirect hernias this suture is started through the anterior rectus sheath, which is approximated to the fascia overlying the pubic tubercle. It is then carried laterally, each stitch being placed superficial to and in between the silk sutures. In this way the silk is buried and a broad approximation of internal oblique muscle to inguinal ligament is established (inset, fig 3). The two structures are accurately approximated, even though some tension results, and the fascia is not used to "bridge a gap." The internal oblique muscle is snugly approximated to the inguinal ligament at the internal ring, thus reestablishing its sphincter-like action. Lateral to the internal ring the fibers of the internal oblique muscle are approximated to the inguinal ligament with two or three sutures. When the internal oblique is poorly attached lateral to the internal ring, a second strip of external oblique aponeurosis may be used as a fascial suture to reinforce the approximation in this region. This is left attached at its lateral extremity, and the suturing begins near the anterior superior iliac spine and proceeds medially to the internal ring (fig 4).

19 Seelig, M. G. Fundamental Principles Underlying the Operative Cure of Inguinal Hernia. *J. A. M. A.* 88:529-532 (Feb 19) 1927.

When orchiectomy is performed concomitantly the two strips of fascia may be used to reinforce the closure of the entire inguinal region from the anterior superior iliac spine to the pubic tubercle. This second fascial suture has been



Fig 3—Fascial suture used to approximate the internal oblique muscle to the inguinal ligament superficial to the interrupted suture. The inset shows the broad approximation thus established.



Fig 4—A second fascial suture being inserted lateral to the internal inguinal ring. The inset shows complete closure of the inguinal defect after division of the spermatic cord preparatory to orchiectomy.

used in 17 cases in this series (see the following paragraphs) but since the three recurrences encountered were all located lateral to the cord its more frequent use seems to be indicated.

The importance of proper and complete closure of the medial portion of the inguinal defect in all hernias cannot be too greatly stressed. This is accomplished first by the interrupted sutures, the most medial of which is used to approximate the edge of the rectus sheath to the pubic tubercle at a point medial to the insertion of the inguinal ligament. The reenforcing fascial suture is then started even more medially and in such a manner that the silk is buried by the approximation of tissue superficial to it. These two rows of sutures establish a broad approximation of muscle to ligament. It is believed that the resulting broad scar, in a portion of which the direction of the fibers is controlled by the use of fascia, is less likely to stretch or give way than the narrower scar produced by the use of either row alone. Evidence in support of this statement is found in the series of cases to be presented in which recurrence did not take place in the portion of the inguinal canal so treated.

After the approximation of the internal oblique muscle to the inguinal ligament is complete and the reenforcing fascial sutures are in place, the external oblique aponeurosis is reapproximated with interrupted sutures. Usually sufficient aponeurosis remains so that it can be approximated superficial to the spermatic cord. In the event that this cannot easily be done, it is approximated deep to the cord. Perfect hemostasis is secured, the subcutaneous tissues are closed and the skin is accurately brought together. Firm pressure is applied by means of a figure of eight bandage.

Nonabsorbable suture material is unquestionably superior to surgical gut in repair of hernias. Fine cotton has proved satisfactory for hemostasis but, because of the occurrence of weak spots at unpredictable intervals, has not been used for approximation. Nylon, which is uniform in size and strength, has been most satisfactory for this purpose. Size 000 has been used to close the transversalis fascia, size 00 to approximate the internal oblique muscle to the inguinal ligament and size 0000 in the external oblique aponeurosis and skin.

Postoperative care in most of the cases reported herein has included ten to fourteen days in bed after operation. During the past year, however, all patients have been allowed to "dangle" on the first postoperative day and to sit in a chair on the following day. Thereafter increasing activity is encouraged, so that by the fourth or fifth postoperative day the patient is walking without assistance. Most patients are now discharged from the hospital on the fifth to seventh postoperative days. To date there has been nothing to suggest that such early ambulation has been detrimental to sound healing.

RESULTS

This series consists of two hundred and one hernias occurring in 170 patients. All were operated on by me using the technic described and every patient followed has been personally examined. One patient died, a mortality rate of 0.5 per cent. For study and comparison the series has been divided into indirect hernias, of which there were one hundred and seventeen, direct hernias, of which there were sixty-seven, and combined direct and indirect hernias, of which there were seventeen.

Table 1 shows the age distribution of patients with all types of hernias. As is generally true, the patients with indirect hernias tend to fall in the younger age groups. Only three hernias occurred in females, two being indirect and one direct.

Of the 169 patients surviving operation, 143, or 84.6 per cent, were followed. Out of a total of two hundred operations one hundred and seventy-two were followed, a follow-up, by operations, of 86.0 per cent.

TABLE 1—Age Distribution

Age	Indirect Hernias (117 Cases)		Direct Hernias (67 Cases)		Combined Direct and Indirect Hernias (17 Cases)	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
15 to 19	11	9.4	0	0.0	0	0.0
20 to 29	17	14.5	1	1.5	0	0.0
30 to 39	18	15.4	8	11.9	0	0.0
40 to 49	21	18.0	18	26.9	6	35.3
50 to 59	27	23.1	21	31.4	6	35.3
60 to 69	17	14.5	15	22.5	3	17.6
70 to 79	6	5.1	4	6.0	2	11.8
Total	117	100.0	67	100.0	17	100.0

Table 2 summarizes the duration of the follow-up by operations. Of the 3 patients who had hernias which recurred, in 2 the condition did so within one year after operation and the third was found to have a small, asymptomatic recurrence five and one-half years after operation.

Emergency operations for strangulation were necessary in two (17 per cent) of the indirect hernias, in seven (10.4 per cent) of the direct

TABLE 2—Duration of Follow-Up (by Operations)

Months	Indirect		Direct		Direct and Indirect		Total	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
6 to 11	15	15.6	7	11.9	4	23.5	26	15.1
12 to 23	39	40.6	11	18.7	6	35.3	56	32.6
24 to 35	17	17.7	14	23.6	4	23.5	35	20.3
36 to 47	11	11.5	5	8.5	0	0.0	16	9.3
48 to 59	5	5.2	9	15.2	2	11.8	16	9.3
60 to 71	6	6.3	7	11.5	0	0.0	13	7.6
72 to 83	3	3.1	6	10.2	1	5.9	10	5.8
Total	96	100.0	59	100.0	17	100.0	172	100.0

hernias and in one (5.9 per cent) of the combined direct and indirect hernias. The high incidence of strangulation among the direct hernias is antithetical to the statement of Andrews and Bissell,⁵ who found this type of hernia "nearly 100 per cent safe" from strangulation. Of the 10 cases of hernias of all types which were strangulated, 8 were followed, in 1 of which the hernia recurred.

Of the entire series of two hundred and one hernias, seven were sliding hernias. Three of these were indirect, all on the left, and four

were direct, one on the right and three on the left. Of the five sliding hernias which were followed, none recurred.

Primary repairs were performed on one hundred and ninety of the hernias of this series, while secondary repairs were done on eleven. Of the eleven recurrent hernias, nine had recurred as direct hernias and in two the recurrences were both direct and indirect. This emphasizes again the importance of securing adequate and permanent reinforcement especially at the medial end of the inguinal canal. The three hernias which recurred after operation in the present series all did so lateral to the spermatic cord at the internal ring and were, therefore, indirect hernias. None recurred as direct hernias. This indicates that the use of nonabsorbable sutures and fascia removed from the external oblique aponeurosis for the closure of the medial portion of the inguinal canal is a superior method for securing sound and permanent healing. It suggests the advisability of the more frequent use of the second strip of fascia to secure the internal oblique muscle to the inguinal ligament lateral to the internal ring. Of the eleven secondary repairs, ten were followed of which one recurred.

In addition to the difference in insertions of the internal oblique muscle already referred to, there is a difference in the quality of this muscle as observed at operation. In some persons that portion extending from the internal ring to its insertion is largely tendinous, with closely knit fibers that make an ideal anchorage for sutures. In others there is little or no tendinous structure and the muscle fibers are friable and loosely joined. In the latter situation the inadequacy of healing after ordinary methods of suture has already been commented on, and it was with the hope of overcoming this difficulty that the technic described was used. In an effort to evaluate the importance of the structure of the internal oblique muscle in relation to the final results with this technic, careful notes on its structure were made at the time of operation. The muscle was designated as poor if it was entirely muscular and obviously weak in structure. It was designated as good when its fibers were mostly or entirely tendinous and as fair when between these two extremes. Satisfactory notes as to the condition of the muscle were available in one hundred and eighty-six herniorrhaphies.

The condition of the internal oblique muscle seemed to have no relation to the duration of the hernia or to whether a truss had been worn. With this technic it also seemed to have no relation to recurrence of the hernias since of the 3 patients who had recurrences, 2 were found to have "good" internal oblique muscles and that of the third was classed as "fair."

A study of figure 5 indicates that the condition of the internal oblique muscle is, in some measure, related to the age of the patient. Thus with each succeeding decade the percentage of patients with "poor" internal

oblique muscles increases. That the poor condition of the internal oblique muscle with advancing years is not related to the type of hernia is indicated by the fact that the percentage of patients with poor muscles increases in about the same proportion with each succeeding decade in each of the three types of hernias.

COMPLICATIONS

One death occurred in this series, in a 51 year old man with a direct inguinal hernia on the right side which had been strangulated for three days before operation. The hernia contained only omentum which was gangrenous. A laparotomy wound was made and the colon thoroughly inspected, no evidence of injury was found. His postoperative recovery

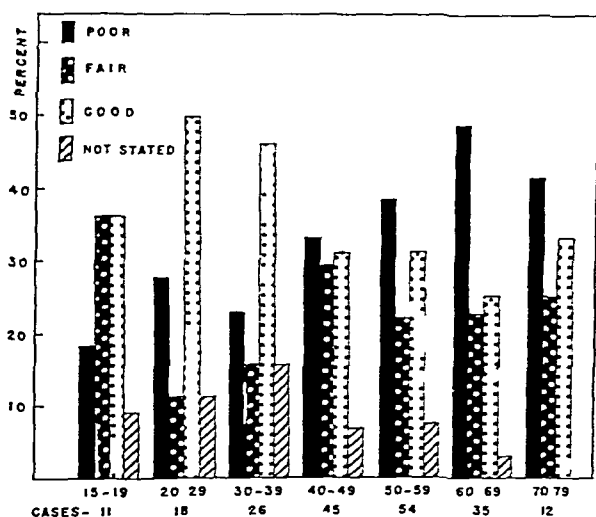


Fig 5—Condition of the internal oblique muscle in relation to age

was good until the fifth day, when he suffered a massive pulmonary embolism. This was treated by ligation of the femoral veins, but thereafter he had a swinging temperature of gradually increasing severity believed clinically to be due to pulmonary sepsis. On the eighteenth postoperative day abdominal distention without tenderness was noted. In spite of vigorous treatment his condition became progressively worse, and he died three days later. At autopsy a resolving infarct of the lower lobe of the right lung was found. The cause of death was acute generalized peritonitis arising from a small perforation of the transverse colon. The cause of the perforation was not evident at autopsy but in retrospect it seems likely that a tiny Richter's type of strangulation of the transverse colon was overlooked at operation.

Other complications were 3 cases of postoperative atelectasis and 1 of bronchopneumonia. There was 1 case of hematoma of the scrotum, that of a patient who had a concomitant orchiectomy. One patient suffered thrombophlebitis of the pampiniform plexus, which was treated by incision of the tunica albuginea, there was no subsequent atrophy of the testis. Wound sepsis occurred in 1 instance, that of a strangulated hernia in a man 73 years of age. The wound healed promptly after drainage of the superficial tissues, and there was no evidence of recurrent hernia four and one-half years after operation.

Concomitant operation was performed with nineteen herniorrhaphies of this series. Hydrocelectomy was done in 4 cases, orchiopexy in 1,

TABLE 3—Summary of Results

	Indirect		Direct		Combined Direct and Indirect		Total	
	No	%	No	%	No	%	No	%
Male	115		66		17		198	
Female	2		1		0		3	
Total	117		67		17		201	
Strangulated	2	1.7	7	10.4	1	5.9	10	5.0
Sliding								
Right	0	0.0	1	1.5	0	0.0	1	0.5
Left	3	2.56	3	4.5	0	0.0	6	3.0
Recurrent hernias	0	0.0	9	13.4	2	11.8	11	5.5
Internal oblique muscle								
Poor	33	32.4	27	40.3	6	35.3	71	35.2
Fair	25	21.4	15	22.4	6	35.3	46	22.9
Good	47	40.2	19	28.4	3	17.6	69	34.3
Not stated	7	5.9	6	8.9	2	11.8	15	7.5
Died	0	0.0	1	1.5	0	0.0	1	0.5
Followed	96	82.0	53	80.0	17	100.0	172	86.0
Recurred	1	1.04	0	0.0	2	11.8	3	1.5

orchiectomy in 11 and appendectomy in 3. Except for the scrotal hematoma noted, none of the patients suffered postoperative complications.

Of the one hundred and seventy-two herniorrhaphies which were followed, three recurred, a recurrence rate of 1.74 per cent. One of these developed after operation for an indirect hernia of only three and one-half weeks' duration. Sixty-six months later a completely asymptomatic recurrence was found at the internal ring, illustrating again the necessity for careful examinations in the determination of end results. The other two recurrences followed repair of combined direct and indirect hernias, one of which was a strangulated recurrent hernia. As noted, the recurrences in these 2 instances also took place at the internal ring. In none of the hernias which recurred was fascia used lateral to the internal ring.

Table 3 summarizes the statistics of this series.

SUMMARY

1 The anatomy and physiology of the inguinal region are reviewed

2 A technic for the surgical repair of inguinal hernias is described in which the following points are stressed (a) an adequate incision, (b) ample exposure and painstaking repair of the transversalis fascia and (c) broad approximation of the internal oblique muscle to the inguinal ligament, lateral as well as medial to the internal ring, by means of a combination of nonabsorbable and fascial sutures

3 The results in a series of two hundred and one herniorrhaphies are presented

SACRAL AGENESIS

Report of a Case

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BECAUSE of the relatively infrequent occurrence or absence of the sacrum, this case is presented. A comprehensive review of the literature is given by Zelig¹

REPORT OF A CASE

An infant girl of 8 months (fig 1) had, in addition to the deformity of the spine, bilateral clubfoot, myelomeningocele and hydrocephalus.

The abdominal and thoracic viscera were examined. Grossly the only abnormality observed was the fusion of the kidneys which were displaced to the left side. On dissection of the lower extremities the peripheral nerves and muscles appeared normal. Microscopic sections were made from representative areas of the central and peripheral nervous systems as well as from muscle groups of the lower extremity. Because of degenerative changes of the nerve tissue an accurate study could not be made. The muscles and tendons on the other hand had not undergone excessive degeneration. The striated muscle and tendon appeared to be normally developed. There was no fatty degeneration or abnormal deposit of fat present.

The Vertebral Column—In the study of the vertebral column the roentgenogram (fig 2) was checked by direct observation of the dissected material (fig 3). The vertebral bodies caudal to the third thoracic vertebra are shown. The ossification centers were single in the fourth and fifth thoracic vertebrae, two and approximately equal in the sixth thoracic vertebra, two with one large and one small in the seventh thoracic vertebra and three small relatively equal ones in the eighth thoracic vertebra. There was a small single ossification center interposed between the eighth and ninth thoracic vertebrae. There were two centers in the tenth thoracic vertebra, one or two small ones between the tenth and eleventh thoracic vertebrae and single ones in the tenth and eleventh thoracic vertebrae. The lumbar vertebrae showed sacralization but did not function effectively as a sacrum. In ossification the lumbar bodies like the last thoracic had single separate centers when viewed from the ventral surface. When viewed from the dorsal surface there was a long crest projecting and extending to the third lumbar vertebra. The ribs were used as the criterion of vertebral level which may or may not

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¹ Zelig, I. M. Congenital Absence of the Sacrum. *Arch. Surg.* 41: 1231 (Nov.) 1940.

have been accurate. The vertebrae caudal to the sixth thoracic became wider, the vertebrae caudal to the twelfth thoracic had assumed the characteristics of sacrum. There was a moderate curve of the vertebral column dorsally and to the right the apex of the lateral right convexity culminated at the eleventh thoracic vertebra. The vertebral arches caudal to the sixth thoracic were open. Caudal to the lowest left rib was a lamina of bone fused to the left side of the vertebral body. Projecting into the vertebral canal from the dorsal surface of the vertebral bodies caudal to the twelfth thoracic was a triangular crest of bone

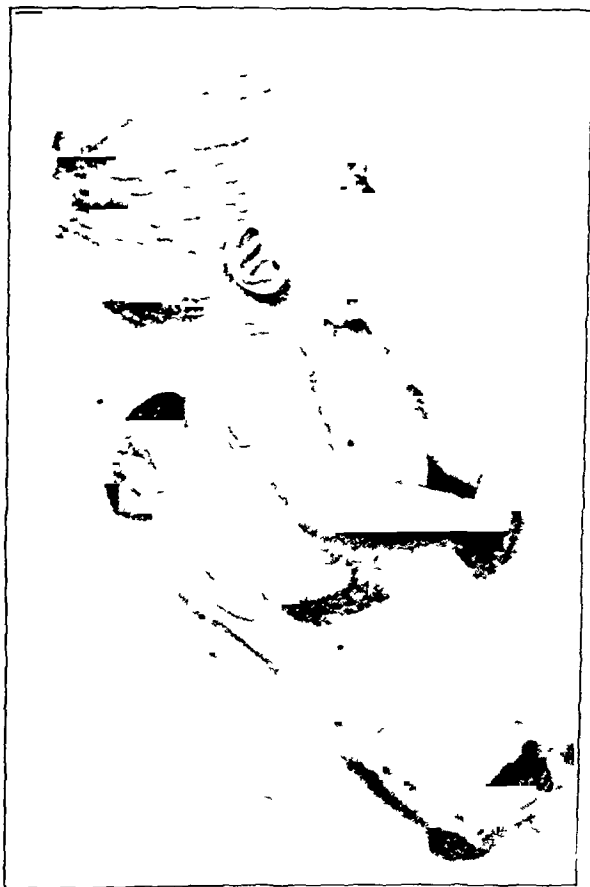


Fig. 1—Photograph of an 8 month infant with hydrocephalus bilateral talipes equinovarus and myelomeningocele

extending for three segments. In this ridge of bone were three additional ossification centers and the ossification center for the body at the cephalic end of the ridge contributed to the formation of the latter.

The four caudal ribs on the left were fused. All the ribs were directed cephalad rather than caudad. The articulation of the left ilium with the vertebral was effected by fibrous tissue that on the right however was brought about by cartilage. The level of iliac articulation is shown in figure 3.

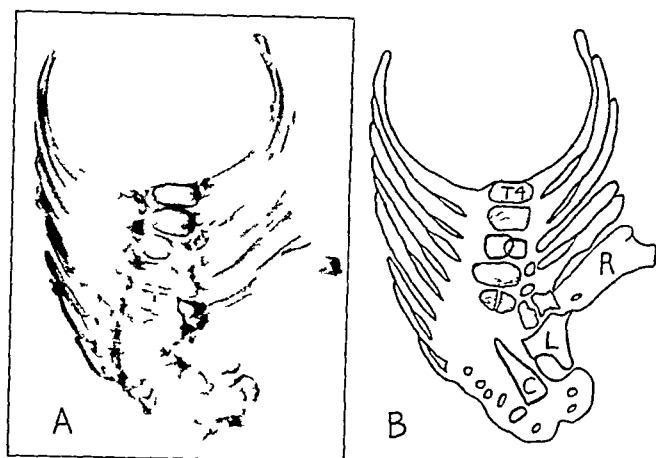


Fig 2—*A*, roentgenogram of the spine caudal to the third thoracic vertebra
B tracing of the roentgenogram *T4* indicates the fourth thoracic vertebra *R*, the
 fused ribs (four) *L* the lamina of bone and *C* the crest of bone



Fig 3—Drawing of the spinal column dorsal view

The Clubfoot—The ligaments were not thickened. The inferior calcaneo-navicular ligament was extremely small, the navicular being in close contact with the sustentaculum tali. The ligaments on the medial and plantar surfaces of the calcaneonavicular-talar joint were short. The tendons occupied abnormal positions due to the altered relationship of the foot to the leg. The metatarsals and cuneiforms appeared normal except for orientation in space. The malleoli were normal in size and shape but not in position. The cuboid, talus and navicular were altered in shape. The calcaneus was not altered in shape but lay in relative abduction and eversion.

ABDOMINAL ACTINOMYCOSIS

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PRIOR to the advent of sulphonamide drugs and penicillin in the treatment of abdominal actinomycosis, the prognosis was extremely grave¹. In 1931 Good² reported 62 cases of actinomycosis of the abdomen that had been studied at the Mayo Clinic and of these he was able to obtain adequate follow-up reports on 50. Twenty-nine of the patients had died, 7 had shown no improvement, 6 patients had shown improvement and the disease had apparently been arrested in 8. In 1936 Wangensteen^{3a} reported 5 cases of abdominal actinomycosis, in all of which the patients had had antecedent appendectomy. Four of the 5 patients died, while the fifth patient showed improvement. Many favorable reports are appearing in the literature substantiating the efficacy of the sulphonamide drugs and penicillin in the treatment of all types of actinomycotic infections. Undoubtedly, the use of penicillin and sulphonamide drugs may result in the cure of minimal abdominal actinomycotic infections. As has been emphasized by Wangensteen^{3a} and Lyons,³ the majority of patients with abdominal actinomycosis require the drainage of abscesses or the extirpation of the granulomatous lesions in order to effect a cure.

Abdominal actinomycosis is most frequently a disease of adolescent and middle-aged males. In the vast majority of cases the etiologic agent is a nonmotile anaerobic organism, *Actinomyces bovis*, the rat fungus. In about one fifth of the cases actinomycosis involves the

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1 (a) Wangensteen O. H. The Role of Surgery in the Treatment of Actinomycosis. *Ann. Surg.* **104**: 752 (Oct.) 1936. (b) Robson, G. M. Actinomycosis Starting as Appendicitis with Extensive Visceral Involvement. *Am. J. M. Sc.* **181**: 692 (May) 1931. (c) Davis, M. I. J. Analysis of Forty Six Cases of Actinomycosis with Special Reference to Its Etiology. *Am. J. Surg.* **52**: 447 (June) 1941. (d) Kolouch F. and Peltier L. F. Actinomycosis. *Surgery* **20**: 401 (Sept.) 1946.

2 Good L. P. Actinomycosis of the Abdomen, *Arch. Surg.* **22**: 307 (1913) 1931.

3 Lyons C. Owen C. R. and Myers W. B. Sulphonamide Treatment of Actinomycotic Infections. *Surgery* **14**: 99 (July) 1943.

abdomen. The usual portal of entry in the abdominal infections is thought to be the alimentary tract.⁴ It is well known that this fungus does not cause peritonitis although it might perforate the wall of the gastrointestinal tract and thus give rise to actinomycotic lesions elsewhere in the abdomen. Rare instances of the passage of the fungus into the abdomen from the thorax have been reported.⁵

Primary actinomycosis of the stomach and duodenum occurs extremely infrequently.⁶ Nathan^{6c} has reported a case of primary actinomycosis of the stomach in which propagation strictly linked to the vascular system could be demonstrated, the infection spread from the primary gastric focus via gastric and portal veins to the liver where actinomycotic abscesses were produced and from the liver through the hepatic veins to the lungs. Actinomycosis involving primarily the jejunum or ileum is extremely rare. Cope⁴ referred to several reported instances of mesenteric involvement in which no lesions of the small intestine were demonstrated.

Apparently a diseased appendix is the site of origin in most cases of abdominal actinomycosis. The disease is frequently diagnosed during or after an operation for suspected acute appendicitis. It may manifest itself as an abscess which surfaces and necessitates surgical drainage or as a draining sinus which persists after appendectomy. Often the diagnosis is established during the routine microscopic examination of the appendix.⁷ Once the organism has passed out of the gastrointestinal tract^{1b} it may result in extensive visceral involvement.

The number of proved actinomycotic lesions involving the colon is small. The lesion usually involves the muscular and serosal coats of the colon leaving an intact mucosa. In our reports of cases (cases 4 and 5) the external wall of the transverse colon was extensively involved; the mucosa remained intact. It is interesting to note that

4 Cope Z. Actinomycosis. London: Oxford University Press, 1938.

5 Ladd W. E. and Bill A. H. Actinomycosis of the Chest with Spread to the Abdomen. *New England J. Med.* **229** 748 (Nov. 11) 1943. Hanes F. M. Actinomycosis of Lungs with Thoracic Fistulae. Abscess of Lower Lumbar Region. Involvement of Liver and Spleen. Poor Therapeutic Results with Various Treatments. *Internat. Clin.* **1** 213 (March) 1942.

6 (a) Shearburn E. W. Actinomycosis of Stomach and Duodenum. Two Cases. *Surgery* **14** 38 (July) 1943. (b) Stravinsky T. Actinomycosis of the Stomach. *J. de chir.* **39** 366 (March) 1932. (c) Nathan H. The Pathways of Propagation in Primary Intestinal Actinomycosis. *Klin. Wchnschr.* **9** 1543 (Aug. 16) 1930. (d) Blain A. W. Primary Actinomycosis of the Stomach. Report of Case. *J. A. M. A.* **100** 168 (Jan. 21) 1933. (e) Nathan H. Primary Gastric Actinomycosis. *Virchows Arch. f. path. Anat.* **273** 480 1929. (f) Fuller C. C. and Wood H. Actinomycotic Granuloma of the Stomach. *J. A. M. A.* **129** 1163 (Dec. 22) 1945.

7 Aycock T. B. and Farris E. M. Appendicitis. The Possible Effects of Sulfonamides on Mortality. *Ann. Surg.* **121** 710 (May) 1945.

in both of these cases (cases 4 and 5) an abdominal mass was palpable prior to operation, and it seems possible that occasionally similar conditions are mistaken for carcinoma. The liver may become involved by direct invasion or by dissemination of the actinomycetes through the portal or systemic circulation. There are many reports in the literature of secondary involvement of the liver, the prognosis in these cases is extremely grave.⁸ While the liver is so frequently involved, apparently only 2 cases of isolated actinomycosis of the gallbladder have been reported.⁹ Involvement of the kidneys, although rare, may occur by direct invasion or by hematogenous spread.⁴

Once the infection is established in any abdominal organ or tissue, it may spread to involve the subphrenic space,¹⁰ the psoas regions or the pelvic structures.¹¹ Tissue planes do not necessarily confine the involvement to any specific area.

The diagnosis is established by demonstration of the typical sulfur granules, by culture or by microscopic examination of the diseased tissue.

Five patients with abdominal actinomycosis have been treated at the Grady Memorial Hospital in the twenty-two months prior to the writing of this paper, without mortality, by the combined use of surgical treatment and prolonged chemotherapy. Apparent cures have resulted in all 5 cases.

REPORT OF CASES

CASE 1—A. B. G., an 18 year old Negro woman, was first admitted to the Grady Memorial Hospital on July 21, 1944, with the complaints of loss of appetite and pain in the left flank during the preceding month. Physical examination revealed a large fluctuant mass in the left lumbar region, and on the day after admission an incision and drainage of the mass yielded 75 cc of thick, yellow, purulent material, which grew only staphylococci on culture. With chemotherapy she improved, and all drainage had subsided within one month.

Six months later she was readmitted, with recurrent abscesses in the left side of the anterior abdominal wall, which required drainage. Repeated microscopic examination of the tissue lining the abscess cavities revealed typical actinomycotic lesions (fig 1). Sulfadiazine (4 to 6 Gm daily) and a total dosage of 1,200,000 units of penicillin were administered. Under this regimen the patient improved and she was discharged from the hospital with instructions to continue the sulfadiazine therapy.

8 (a) Dobson, L. and Cutting, W. C. Penicillin and Sulfonamides in the Therapy of Actinomycosis, *J. A. M. A.* **128** 856 (July 21) 1945. (b) Cope.⁴

9 Sullivan, R. C., Francona, N. T., and Ragins, A. B. Actinomycosis of the Gallbladder, *J. A. M. A.* **113** 408 (July 29) 1939. Mayo Robson, A. W. Actinomycosis of the Gallbladder, *Tr. M. & Chir. Soc.* **88** 225, 1905.

10 Graves, A. M. and Ochsner, A. Actinomycosis of the Subphrenic Space, *Am. J. Surg.* **23** 54 (Jan.) 1934.

11 Rashbaum, M., and McIntosh, H. C. Pelvic Actinomycosis Treated by Surgery and Roentgen Ray, with Recovery, *Am. J. Obst. & Gynec.* **47** 64, (June) 1944.

In August 1945 the patient was again seen and found to have two draining sinuses, one in the left flank and the other in the left inguinal region, from which sulfur granules were recovered. The patient had discontinued the sulfadiazine therapy shortly after leaving the hospital. Treatment at this time consisted of sulfadiazine (4 to 6 Gm daily) and total dosage of 5,085,000 units of penicillin. With this therapy the sinuses practically ceased to drain, the sulfur granules disappeared and the patient's general condition improved to such extent that she was discharged on Oct. 11, 1945.

The patient was followed in the outpatient department until July 12, 1946, and during this entire time had continued the sulfadiazine therapy. On this date she was readmitted to the hospital because the drainage from the sinuses in the left flank and left inguinal region had increased. Roentgenographic studies following

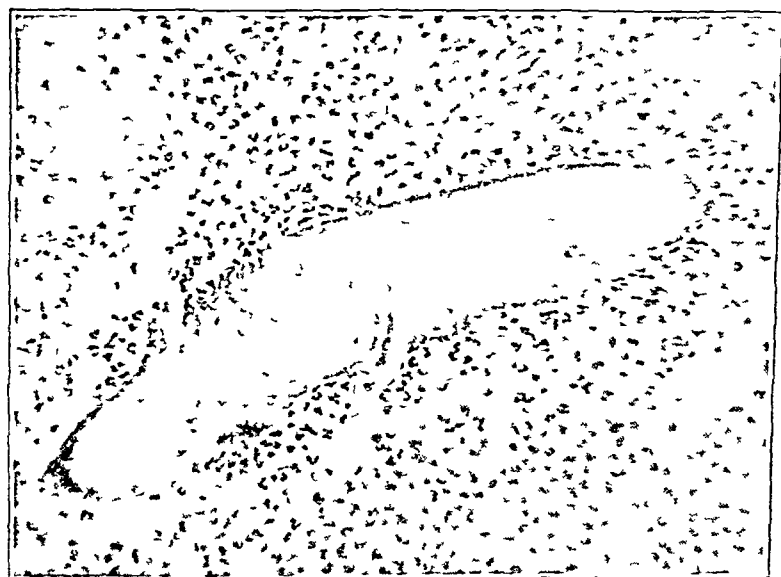


Fig 1—Photomicrograph showing granule or actinomycosis in abscess on the margin of sinus tract on the anterior abdominal wall (taken from case 1)

the injection of iodized oil into the sinus tracts revealed a fistulous communication with the sigmoid colon.

On August 2, after preparation of the bowel with succinylsulfathiazole, an extensive surgical excision of the draining sinuses was performed. Through a separate incision the distal one half of the transverse colon, the descending colon and the sigmoid colon were resected, including a block dissection of the enlarged regional nodes, and an anastomosis of the transverse colon to the rectum was done. Numerous sections as well as cultures of the surgically excised specimens revealed no evidence of actinomycotic infection. The large denuded area in the left abdominal wall and flank was covered with split thickness skin grafts approximately four weeks later and by November 1 complete healing of the wound had occurred. During this last period of hospitalization the patient received 6 Gm of sulfadiazine per day in addition to 400,000 units of penicillin daily.

CASE 2—R T, A 32 year old Negro man, was admitted to the Grady Memorial Hospital on Jan 30, 1945. Eight days prior to admission the patient began to feel weak and experienced suprapubic pain on urination. Five days later he began to have nausea and vomiting, the pain shifted into the right lower quadrant and became severer.

Physical examination on admission revealed a temperature of 100.6 F, a pulse rate of 100 and a respiratory rate of 18. There was a mass palpable in the suprapubic region, extending into the right lower quadrant. Rectal examination revealed the mass to extend beyond the midline to the left. The white blood cell count was 15,000. Microscopic examination of the urine revealed 15 to 20 white blood cells per high power field.

The diagnosis of appendical abscess was made, and the patient was treated with nasogastric suction, parenteral administration of fluids and sulfadiazine subcutaneously. The mass did not decrease in size, and on February 5 an incision and drainage through a McBurney incision on the right side were performed. Approximately 50 cc of yellow purulent material was obtained. The wall of the abscess cavity was thick, edematous and lined with granulation tissue. A large amount of the granulation tissue was scraped out of the wound which was then packed open. A diagnosis of actinomycosis was confirmed by culture of the purulent material and by microscopic examination of the granulation tissue.

Postoperatively the patient was given sulfadiazine (4 to 6 Gm daily) and a total dosage of 2,460,000 units of penicillin. The wound healed and the patient was discharged on April 10, 1945, in good clinical condition. The patient did not visit the surgical clinic regularly after his discharge but he did continue the sulfadiazine therapy (4 Gm daily) until readmission on Aug 24, 1946. An elective appendectomy was performed on August 27 through a right paramedian incision. The appendix contained a large fecalith and was bound to the sigmoid colon. There was no evidence of active actinomycotic infection present and the wound was closed without drainage.

Microscopic examination of the appendix and cultures of its contents revealed no evidence of actinomycotic infection. The patient was given sulfadiazine (4 Gm daily) as well as penicillin (50,000 units every three hours intramuscularly) during this stay in the hospital. He remained afebrile and at the time of discharge on September 6 the wound had healed without incident.

The patient was seen in the outpatient surgical clinic on Nov 1, 1946 at which time he appeared to be entirely well.

CASE 3—J B, a 53 year old Negro man was admitted to the Grady Memorial Hospital on Feb 26, 1945. Five days before admission the patient had gradual onset of pain in the region of the umbilicus, which gradually spread over the entire abdomen. Although the pain was generalized the point of maximum tenderness was in the right lower quadrant. The patient began vomiting one day before admission and had vomited three or four times.

Physical examination on admission revealed a temperature of 100 F, a pulse rate of 90 and a respiratory rate of 16. There were moderate abdominal distention and generalized abdominal tenderness. Auscultation revealed hyperperistalsis. The point of maximum rebound tenderness was in the right lower quadrant but no mass was palpable. A roentgenogram of the abdomen revealed changes consistent with the diagnosis of small intestinal obstruction in the lower part of the ileum.

A Miller-Abbott tube with attached Wangenstein suction was used for several days and the patient was given parenteral therapy with fluid and electrolytes.

Sixteen hours after admission an operation was performed through a right paramedian incision. There was approximately 500 cc of thin purulent material free in the abdominal cavity. A perforated appendix surrounded by edematous and indurated tissues was found in the right lower quadrant. The appendix was removed and the abdomen was closed without drainage.

On microscopic examination the appendix was found to contain actinomycetes. The fluid aspirated from the abdominal cavity grew beta hemolytic streptococci and *Staph. albus* on culture. The sulfadiazine therapy was continued postoperatively and on the fourth postoperative day administration of penicillin (10 000 units every three hours intramuscularly) was begun. On the fifth postoperative day an abscess developed at the lower end of his incision which was drained. Administration of penicillin was discontinued on the twenty-first postoperative day after the patient had received a total of 1,230 000 units. There was no sinus tract or drainage after the twenty-second postoperative day.

He was discharged on March 27 1945 with instructions to continue his sulfadiazine therapy 4 Gm daily.

He was seen periodically in the outpatient surgical clinic and remained asymptomatic until June 23 1946. On this date he had superficial ulceration at the site of the previous operative incision. The wound was thoroughly scraped at this time, and microscopic examination of the scrapings of the wound showed no evidence of actinomycotic infection. The wound was completely healed on July 11, 1946.

When last seen in the surgical clinic on Nov. 1 1946 the patient was asymptomatic and continuing his sulfadiazine therapy (4 Gm daily).

CASE 4—E. H., a 9 year old Negro boy, was admitted to the Grady Memorial Hospital on March 22 1945. His history dated back to January 1945 at which time he had been ill for about two weeks with abdominal pain, vomiting and diarrhea. He recovered from this attack and apparently had been getting along fairly well until four days prior to admission when he began to complain of generalized abdominal pain which was apparently severest in the right lower quadrant. The pain persisted and on the day before admission he experienced nausea and vomiting. Bowel movements remained regular and normal in character.

Physical examination on admission revealed a temperature of 101 F, a pulse rate of 100 and a respiratory rate of 20. There was a well defined movable soft exquisitely tender mass measuring approximately 5 by 7 cm just to the right of the umbilicus. There was moderate muscular spasm throughout the abdomen. Rectal examination was noncontributory. The white blood cell count on admission was 17,500; the urinary examination was noncontributory.

He was given sodium sulfadiazine subcutaneously on admission and other supportive measures were instituted. The day following admission exploratory celiotomy was performed and an inflammatory mass measuring approximately 8 by 4 by 2 cm was found on the antimesenteric border of the transverse colon. An obstructive resection of the transverse colon was done and on the fifth postoperative day the clamps were removed. Microscopic examination of the specimen revealed actinomycosis involving the transverse colon.

On April 2 1945 a spur-crushing clamp was applied to the septum between the two segments of exteriorized bowel. On May 12 after preparation with succinylsulfathiazole the colostomy was closed by an extraperitoneal procedure, and the bowel was dropped beneath the anterior rectus sheath. The incision was completely healed on May 29. He received sulfadiazine 1 Gm four times daily while in the hospital and was discharged with instructions to continue use of sulfadiazine 1 Gm twice daily.

The patient was readmitted on July 17, 1945, at which time he was complaining of generalized abdominal pain associated with nausea and vomiting. A diagnosis of partial intestinal obstruction was made, and a regimen of conservative management was instituted. With nasogastric suction, penicillin and sulfadiazine therapy he rapidly improved, and on July 23 a study after a barium enema revealed that the transverse colon was slightly constricted at the site of the previous resection. A series of roentgenograms of the gastrointestinal tract on July 26 was entirely normal.

The patient was discharged from the hospital on July 28, with instructions to continue to take sulfadiazine, 1 Gm twice daily. At the last visit to the outpatient surgical clinic, on Nov 1, 1946, the patient was asymptomatic, gaining weight and continuing the sulfadiazine therapy, 2 Gm daily.

CASE 5—K. M., a 39 year old Negro man, was admitted to the Grady Memorial Hospital on Nov 20, 1945. On November 18 he had been awakened at night with intermittent pain in the right paraumbilical region. The following morning the pain had localized in the right lower quadrant, where it had remained until the patient's admission to the hospital.

Physical examination on admission revealed a temperature of 99.2 F, a pulse rate of 100 and a respiratory rate of 20. There was tenderness over McBurney's area, rebound tenderness and moderate muscle spasm in the right lower quadrant. A tender mass was palpable just to the right of the umbilicus. Examination of the urine was noncontributory. The white blood cell count was 9,950.

Shortly after admission an exploratory celiotomy through a right paramedian incision was performed. A large inflammatory mass, which was freely movable, was found on the antimesenteric border of the transverse colon. The regional lymph nodes were not enlarged, and there was no attachment of the mass to the surrounding structures. An obstructive resection of 15 cm of the transverse colon was performed.

Examination of the specimen revealed a firm mass adherent to the antimesenteric border of the transverse colon, which measured 12 by 8 by 6 cm and weighed 330 Gm. The mucosa of the colon was not involved by the inflammatory process (fig 2). Microscopic examination of the specimen revealed many colonies of actinomycetes.

The postoperative course was uneventful, and the patient was discharged from the hospital on December 20. He had received sulfadiazine (4 to 6 Gm daily) while in the hospital and was instructed to continue this therapy.

The patient returned on December 27, and on December 29 colostomy closure was performed. Again sulfadiazine therapy was administered, and he was discharged on Jan 7, 1946.

The third hospital admission was on March 28, 1946. The patient stated that he had been taking sulfadiazine (4 Gm daily) since his last discharge from the hospital. He stated that one day before this admission he experienced a severe cramping pain in the left upper quadrant. There was some nausea and vomiting. Physical examination on admission revealed a temperature of 100.6 F, a pulse rate of 100 and a respiratory rate of 22. There was moderate abdominal distention, rebound tenderness in the left upper quadrant and hyporeactive peristalsis. A roentgenogram of the abdomen (upright and recumbent positions) revealed several loops of distended intestine throughout the midabdomen. Several intestinal fluid levels were present in the intestinal loops. The white blood cell count was 12,500.

A conservative regimen was decided on, and therapy consisted of the following Miller-Abbott intubation, parenteral administration of sulfadiazine (6 Gm daily), 20,000 units of penicillin every three hours (intramuscularly) and other supportive therapy.

On April 4 fluoroscopic and roentgenologic studies of the abdomen revealed a large abscess cavity filled with fluid and gas in the left side of the midabdomen and adjacent to the anterior abdominal wall. On April 5 incision and drainage were performed through a left midrectus incision. On opening the peritoneum directly over the abscess, there was an immediate gush of foul, fecal, odorous fluid material from the cavity. Approximately 2000 cc of fluid was aspirated from the cavity which appeared to be well walled off by loops of intestine from the general peritoneal cavity. Culture as well as microscopic examination of



Fig 2—Cross section through the transverse colon (taken from case 5), showing intact mucosa with a large tumor-like actinomycotic lesion attached to antimesenteric border of colon (Centimeter rule in background)

biopsy material taken from the wall of the cavity, revealed no evidence of actinomycotic infection.

Postoperatively a small intestinal fistula developed at the operative site. Intramuscular administration of penicillin, as well as supportive measures, was continued. It was necessary to discontinue sulfadiazine therapy on April 11 because of renal complications.

On June 28, after preparation with succinylsulfathiazole, celiotomy was performed through a right paramedian incision, and the fistula was found to be in the ileum. The lumen of the small intestine just distal to the fistula was almost completely obliterated. A 30 cm segment of the involved ileum was resected and an end to end anastomosis was performed. The fistulous tract in the abdominal wall was excised. Cultures as well as numerous sections of the surgically excised tissues revealed no evidence of actinomycotic infection.

On the thirteenth postoperative day a partial small intestinal obstruction developed which was completely relieved by Miller-Abbott intubation. Healing of the laparotomy wound was per primam. The area of the fistulous tract gradually filled in with granulation tissue and by July 25 it was completely healed. Penicillin (20,000 units every three hours, intramuscularly) was administered during this entire stay in the hospital.

He was discharged on July 27. Because of the renal complications which developed during the patient's last admission to the hospital, further administration of sulfadiazine was not advised. When last seen in the surgical outpatient clinic, on Nov. 1, 1946, the patient had gained 40 pounds (18 kg.) in six months and had no complaints.

COMMENT

Potassium iodide and thymol¹² were extensively employed in the treatment of actinomycotic infections before the advent of sulfonamide drugs and penicillin, with some apparent success. Other therapeutic agents which have been used in actinomycotic infections are irradiation, foreign protein, neoarsphenamine, copper sulfate¹⁴ and combined gold vaccine therapy.¹³ Christopher¹⁴ has reported the use of zinc peroxide in conjunction with surgical treatment and administration of sulfonamide drugs in the treatment of abdominal actinomycosis.

That chemotherapeutic agents have been valuable in the treatment of actinomycosis is now a well established fact.¹⁵ Sulfadiazine has

12 Myers H B. Thymol Therapy in Actinomycosis. *J A M A* **108** 1874 (May 29) 1937. Wangenstein O H, in discussion on Joyce T M. Thymol Therapy in Actinomycosis. *Ann Surg* **108** 915 (Nov.) 1938. Etter I E and Schumacher, F L. Pulmonary Actinomycosis. Recovery After Thymol Therapy. *J A M A* **113** 1023 (Sept. 9) 1939. Bancroft, F W, and Stanley Brown M. The Treatment of Actinomycosis with Thymol, *Ann Surg* **108** 468 (Sept.) 1938. Joyce T M. Thymol Therapy in Actinomycosis, *ibid* **108** 910 (Nov.) 1938.

13 von Szathmari Z. Gold and Vaccine Therapy of Actinomycosis of Genitals and Intestines. *Arch f Gynäk* **163** 594, 1937.

14 Christopher, F and Karabin J E. Abdominal Actinomycosis. Recovery Following Surgical Treatment and Use of Zinc Peroxide and Sulfanilamide. *Ar J Surg* **50** 371 (Nov.) 1940.

15 (a) Dorling G C and Eckhoff, N L. Chemotherapy of Abdominal Actinomycosis. *Lancet* **2** 707 (Dec. 7) 1940. (b) Ogilvie, W H. Abdominal Actinomycosis Treated with Sulfapyridine. *Brit M J* **2** 254 (Aug. 25) 1940. (c) Walker O. Sulfanilamide in the Treatment of Actinomycosis. *Lancet* **1** 1219 (May 28) 1938. (d) Hall W E B. Sulfanilamide in Actinomycosis, *J A M A* **112** 2190 (May 27) 1939. (e) Sudler M T and Johnson C B. Treatment of Actinomycosis with Sulfanilamide. Report of Two Cases. *J Kansas M Soc* **40** 330 (Aug.) 1939. (f) Billington R W. Actinomycosis Treated with Sulfapyridine. *Brit M J* **1** 326 (March 4) 1944. (g) Hollenbeck W F and Turnoff D. Actinomycosis Treated with Sulfadiazine. *J A M A* **123** 111 (Dec. 25) 1943. (h) Miller E M and Fell E H. Sulfanilamide Treatment of Actinomycosis. *ibid* **112** 731 (Feb. 25) 1939. (i) Wilkinson F I. Actinomycosis. Treatment with Sulfanilamide. *J Pediatr* **18** 565 (June) 1941.

proved to be highly fungistatic in both clinical¹⁶ and in vitro¹⁷ studies Lyons¹⁶ has emphasized the necessity of continuous sulfonamide therapy (4 Gm daily over a period of many months) in order to prevent recurrence and to effect a cure.

The status of penicillin in the treatment of abdominal actinomycosis is not yet clear, although the recent reports on its clinical use are encouraging.¹⁸ *Actinomyces bovis* is susceptible to penicillin in vitro.¹⁷ Keenev^{17c} stated that *Actinomyces bovis*, in regard to its susceptibility to penicillin, is more like a bacterium than like a fungus. He found that the actinomyces were inhibited and apparently killed by a concentration of 0.01 Oxford unit of penicillin per cubic centimeter of medium. Dobson and Cutting^{18a} studied the relative chemotherapeutic potency of sulfadiazine and of penicillin against *Actinomyces bovis*. They concluded that 'unless exceptionally high concentrations of penicillin are used, this drug appears to be slightly inferior to sulfadiazine against various strains of actinomyces in vitro and that the combination of the two drugs in usual dosage does not improve the results'. Many more clinical reports will have to be analyzed before the value of penicillin in the treatment of this disease can be definitely established. We have used it in all our cases in conjunction with sulfadiazine therapy.

MacCharles M R and Kippen, J W. Three Cases of Actinomycosis Treated with Sulfanilamide. *Canad M A J* **41** 490 (Nov.) 1939. (b) Dobson L, Holman E., and Cutting W C. Sulfanilamide in Therapy of Actinomycosis. *J A M A* **116** 273 (Jan 25) 1941. (c) Mitchell H S. Sulfapyridine in Actinomycosis. *Canad M A J* **46** 584 (June) 1942. (m) Keenev E L. Ajello L and Lankford E. Studies on Common Pathogenic Fungi and on *Actinomyces Bovis*. II. In Vitro Effect of Sulfonamides. *Bull Johns Hopkins Hosp* **75** 393 (Dec.) 1944. (n) Lyons, Owen and Avers.³ (o) Dobson and Cutting.^{18a}

16 Lyons, Owen and Avers.³ Dobson and Cutting.^{18a}

17 Keenev, Ajello and Lankford.^{17m} Cutting W C and Gebhardt L P. Inhibitory Effects of Sulfonamides on Cultures of *Actinomyces Hominis*. *Science* **94** 568 (Dec 12) 1941.

18 (a) Walker J M and Hamilton J W. The Treatment of Actinomycosis with Penicillin. *Ann Surg* **121** 373 (March) 1945. Jones T E and Brownell T S. Treatment of Actinomycosis with Penicillin. *Cleveland Clin Quart* **12** 32 (Jan.) 1945. McCrea J H, Steven R A and Williams O O. Actinomycotic Infection of the Soft Tissues of the Neck. *J Lab & Clin Med* **30** 509 (June) 1945. Herrell W E and Kennedy R L J. Penicillin. Its Use in Pediatrics. *J Pediat* **25** 505 (Dec.) 1944. Shulman H. Penicillin in Pleural and Abdominal Actinomycosis. *Case Report M Bull Vet Admin* **21** 230 (Oct.) 1944.

19 (a) Abraham E P, Chain E, Fletcher C M, Gardner A D, Heatley N G, Jennings M A and Florey H W. Further Observations on Penicillin. *Lancet* **2** 177 (Aug 16) 1941. (b) Fisher A M. The Antibacterial Properties of Crude Penicillin. *Bull Johns Hopkins Hosp* **73** 343 (Nov.) 1943. (c) Keenev E L and others. Studies on Common Pathogenic Fungi and on *Actinomyces Bovis*. III. In Vitro Effect of Penicillin. *ibid* **75** 410 (Dec.) 1944. (d) Dobson and Cutting.^{18a}

The value of chemotherapy in the treatment of abdominal actinomycosis is supported by the fact that, after its prolonged use, the numerous microscopic sections and repeated cultures of the surgically excised tissue showed no evidence of actinomycotic infection in 4 of the 5 cases reported here

As has been previously pointed out in this paper, surgical treatment is of utmost importance in the treatment of abdominal actinomycosis.³ Surgical drainage of all abscesses and excision of diseased tissue, insofar as can be achieved, remains a most important factor in the treatment of this disease

SUMMARY

1 A brief resume of the clinical manifestations and therapy of abdominal actinomycosis is presented

2 Five cases of abdominal actinomycosis treated at the Grady Memorial Hospital are reported. Apparent cures have resulted in all 5 cases

3 Prolonged chemotherapy combined with adequate surgical treatment is presented as the treatment of choice in abdominal actinomycosis

Dr William C Ward, Emory University School of Medicine, Emory University, Georgia, gave advice and many helpful suggestions

20 Wangenstein^{1a} Lyons, Owen and Avers³

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy
of Orthopaedic Surgeons

X INFANTILE PARALYSIS

Prepared by

C E IRWIN M D

WARM SPRINGS GA

(Continued from page 364)

Etiology and Pathogenesis—According to Toomey,²⁶⁵ the portal of entry for the virus of poliomyelitis is by way of the gastrointestinal tract rather than by the olfactory bulb. In reviewing histories of affected persons, the author noticed that they usually had some symptom referable to the gastrointestinal tract. An early sign was paralysis of the gastrointestinal tract and commonly paralysis of the bladder. These symptoms were noted long prior to the development of somatic paralysis of the periphery. Monkeys were used for experimental work. The urinary flow was blocked in 6 animals by the production of uroliths with sulfonamide drugs. In 6 animals the virus was injected intracerebrally. In those receiving the drug urinary retention developed, and they showed symptoms of the disease three or four days before the control animals. The same type of animal was used to show that the disease could be produced by way of the gastrointestinal tract. Because it was felt that *Macaca rhesus* monkeys had a natural resistance against the disease, they were operated on and the virus injected in two ways: (1) subserosally, to allow direct approach to the peripheral nerve in the intestine, and (2) directly into the lumen of the intestine after it had been clamped. After the experimental work, Toomey contended that the body absorbs the virus along the gastrointestinal tract from the stomodeum downward, usually in the vicinity of the ileocecal valve.

Fox and Sennett²⁶⁶ point out that poliomyelitis occurs infrequently in pregnancy, some 85 cases having been reported. They present 4 cases from their own clinic in which pregnant women acquired acute anterior poliomyelitis and briefly review the literature on this subject. Their conclusions were as follows: 1. Pregnancy increases susceptibility to poliomyelitis. 2. This increased susceptibility may possibly be due to the changes in ovarian secretion at this time, although pituitary dysfunction and fetal hormones upsetting the mother's endocrine balance may also be suspected. 3. Poliomyelitis in the mother does not affect the newborn child, nor does it hamper normal spontaneous delivery.

²⁶⁵ Toomey, J. A. Poliomyelitis, *Kentucky M J* **43** 111-113 (April) 1945

²⁶⁶ Fox, M. J. and Sennett, L. Poliomyelitis in Pregnancy, *Am J M Sc* **209** 382-387 (March) 1945

Avery²⁶⁷ reports a clinical case because of unusual features of syphilitic involvement of the spinal cord. A 26 year old white woman entered the hospital in January 1926, complaining of progressive weakness of the legs of two months' duration. The onset was insidious. Weakness of the legs was noticed when she was forced to run or to climb stairs. When she fell, great difficulty was experienced in rising to her feet. No pain, numbness or disturbance of the sphincters was noted. Examination revealed motor weakness of the lower extremities, with impairment of adduction, abduction and rotation of the thigh on the left hip, with little weakness of the same regions on the right. The patellar tendon reflex on the left was weak, and that on the right was brisk. The same was true of the reflexes of the achilles tendon. Wassermann test of the blood and spinal fluid gave strongly positive reactions. The spinal fluid contained 47 lymphocytes, it elicited a positive globulin reaction and the gold curve was 0123310000.

Three types of syphilis of the spinal cord are considered—meningomyelitis marginalis, transverse myelitis and intermittent claudication of the spinal cord. A diagnosis of subacute syphilitic anterior poliomyelitis seems to best explain the clinical course, the character and the distribution of symptoms. The poliomyelitic syndrome due to syphilis is not infrequently encountered.

The patient was placed on antisyphilitic therapy and had recovered all her motor power and had negative serologic reactions at the end of one year. She was followed for fourteen years during which time no recurrence of the difficulty was observed.

Green,²⁶⁸ in commenting on the destructive action of the poliomyelitis virus, points out that the pathologic process in the central nervous system is generalized, involving the spinal cord, meninges, brain, medulla pons and posterior ganglions. Reference is made to recent work which suggests that the effects of the disease arise mainly by the intraneuronal action of the virus and that the interstitial manifestations are secondary.

The original considerations of the disease as outlined by Robert Lovett for the Harvard Infantile Paralysis Commission in 1916 are listed. A discussion of the three phases is made. Various evolutionary changes in therapy at the Harvard Clinics have come about. Mention is made of the change from complete immobilization for long periods in plaster splints to much shorter intervals. Guided active motion started earlier in the acute stage than formerly.

Comments are made concerning muscle analysis, hot packing, reeducation of muscles and early walking as outlined by Sister Kenny. It

267 Avery L. W. Infective Meningomyelitis with Subacute Anterior Poliomyelitis. Clinical Case Report. *Urol. & Cutan. Rev.* 49:89-90 (Feb.) 1944.

268 Green W. T. Diagnostic and Therapeutic Considerations in Poliomyelitis. *Rhode Island M. J.* 28:89-93 (Feb.) 1945.

author states the opinion that the Kenny treatment is not so radical a change in therapy as the terminology and the comments would suggest.

Diagnosis—Because there was a group of patients seen during the 1943 epidemic of poliomyelitis who had symptoms suggestive of poliomyelitis which still could not be classified properly as such, Paul and his associates²⁶⁹ attempt to clear up a confusing problem by reviewing the cases of 10 patients with this unnamed syndrome. The outstanding symptoms of the illness were elevated temperature, headache, pain in limbs, vomiting and lymphadenopathy. These were of sudden onset with chills. Physical signs were almost absent and results of laboratory studies, including lumbar puncture were essentially normal. All patients recovered without complications or sequelae.

Various other epidemics of similar types are described and such diseases as "pretibial fever, Rocky Mountain spotted fever, typhus typhoid, tularemia and influenza are closely related entities to be considered. No term is given for the syndrome and the authors are content to designate the malady as a 'dengue-like' disorder. The cause of the disease is unknown, and were it not for the awareness of poliomyelitis in the vicinity these patients would not have been originally admitted to the hospital with this tentative diagnosis.

Farril²⁷⁰ in his article reveals that in Latin America poliomyelitis exists throughout the year spasmodically and endemically. He states that diagnosis presents a challenge and that if there is ever a doubt of a diagnosis one should always treat the disease as poliomyelitis. He reports the use of serum in his cases and adheres to the belief that this is a valuable adjunct in the early stages. He then considers some of the commoner diseases which must be ruled out in diagnosing early poliomyelitis. These include meningitis, encephalomyelitis, lymphocytic choriomeningitis, rheumatic fever, postinfectious meningitis, trichinosis, acute rheumatism, epiphysitis, osteomyelitis, peripheral neuritis, post-diphtheritic paralysis and polyneuritis. He also considers many of the less common neurologic syndromes.

In their electromyographic studies, Kohn and his co-workers²⁷¹ have come to the following conclusions: 1. Paretic and paralyzed muscles involved in poliomyelitis infrequently show electromyographic evidence of spasm while at rest. 2. A small percentage of such muscles show constant potential discharges when stretched. Intermittent discharges are

269 Paul W. D., Antes E. H. and Sahs A. L. Dengue-Like Fever Occurring in Iowa During the Poliomyelitis Epidemic of 1943. *Arch. Int. Med.* **75**: 184-191 (March) 1945.

270 Farril J. Differential Diagnosis of Infantile Paralysis. *Medicina Mexico* **24**: 467-470 (Dec. 25) 1944.

271 Kohn P. M., Zucker E. M. and Toomey J. A. Electromyographic Studies in Poliomyelitis. *J. Nerv. & Ment. Dis.* **102**: 433-439 (Nov.) 1945.

found more frequently. 3 Evidence of disorganization of the neuromuscular mechanism as manifested by disordered reciprocal and crossed innervation is a common finding.

It is the opinion of Frohring and his associates^{2,2} that changes in sensory involvement have not been demonstrated in patients with poliomyelitis because the ordinary methods of measurement are too gross to detect minute quantitative or qualitative changes in sensation. A recently developed pallesthesiometer has been found satisfactory to test these patients. The pallesthesiometer quantitatively measures the vibratory sense. To determine the vibratory sense at various points on the body, the disk is applied locally, and the operator gradually increases the amplitude of vibration until the patient first becomes aware of the vibration.

A second and more delicate evaluation of the vibratory sensibility can also be made, namely, the adaptation, or "fatigue," response. Four test points were selected and marked in ink, thereby assuring the same spot for various readings and lessening the chance for variables. Eleven patients with poliomyelitis were tested. Nine showed lowered thresholds, 1 showed a considerably lowered threshold at one of the six sites tested, and 1 showed no deviation from normal. Interesting is the comment that in addition to the clinical demonstration of involvement of the sensory neurons in poliomyelitis evidence pointing to involvement of the intercalated (internuncial) neurons has been reported. It is becoming increasingly clear that the term acute poliomyelitis of the anterior area describes only one part of the pathologic picture.

Various types of disease affecting the nerve tissues produce a type of abnormal adaptation curve, as recorded by the pallesthesiometer, characterized by a slow phase of recovery following a heavy prolonged vibratory stimulus. By means of the vibrator, sensory changes which previously had not been demonstrated in poliomyelitis, despite the obvious pathologic changes in the posterior part of the cord and in sensory ganglions, have now been shown to exist.

Prevention—Wood and Rusoff^{2,3} found that trypan red when injected intraperitoneally into mice greatly lowered the incidence of the infection in mice inoculated intraperitoneally with the neurotropic MM virus. The protective action of the dye is overcome if the virus is inoculated in too high concentration. These same conditions and results apply to cotton rats. With monkeys and a typical poliomyelitis virus no protection was observed against the virus inoculated intraperitoneally.

272 Frohring, W O, Kohn, P M, Bosma, J F, and Toomey, J A. Changes in the Vibratory Sense of Patients with Poliomyelitis as Measured by the Pallesthesiometer, *Am. J. Dis. Child* 69:89-91 (Feb.) 1945.

273 Wood, H G, and Rusoff, I I. Protective Action of Trypan Red Against Infection by Neurotropic Virus. *J. Exper. Med.* 82:297-309 (Nov.) 1945.

According to Utter, Reiner and Wood,²⁷⁴ experiments with mouse brain homogenates show that the anaerobic glycolysis of such preparations can be increased tenfold by the addition of appropriate coenzymes and phosphate esters. The previously reported alterations in anaerobic glycolysis during the course of poliomyelitis, as measured with preparations with a low activity are believed to be of doubtful value so far as the changes may be related to any specific phase of metabolism. In order to obtain this type of information, the experiment usually must be designed specifically to measure the desired factor.

Foley and Aycock²⁷⁵ found that treatment of castrate female and normal male and female mice with alpha-estradiol dipropionate or diethylstilbestrol enhanced resistance against infection by intranasal instillations of a suspension of mouse-hamster poliomyelitis virus. Similar treatment did not enhance resistance against infection with the same virus when the virus was injected intraperitoneally. Other experiments with the Lansing strain of poliomyelitis virus showed that the enhancing effect of estrogen on resistance to infection could not be demonstrated by intracerebral injection of the virus in mice. These results are similar to those obtained earlier in monkeys, in which treatment with estrogen enhanced resistance against infection by intranasal but not by intracerebral administration of virus.

According to Toomey and Takacs,²⁷⁶ cetamic detergents such as 1/8 per cent solution of phemerol chloride, cetylpyridinium chloride, "cetamium" (cetyl trimethyl ammonium bromide) and zephiran chloride are tolerated by eastern cotton rats when injected intracerebrally, intranasally, subcutaneously and intraperitoneally in doses up to 1 cc respectively. Treatment of a suspension of poliomyelitis virus with cetamic solution did not protect animals against the disease.

Epidemiology and Statistics—Following the investigations of Mr. Hedge Peterson, director of the State Meteorological Institute of Denmark, as to the theoretic and statistical analysis of the growth and decline of different types of epidemics, Wold²⁷⁷ made similar studies on Swedish epidemics of poliomyelitis. Mr. Peterson considered three types of epidemics: (a) the epidemics caused and supported by infections from the

274 Utter, M. F., Reiner, J. M. and Wood, H. G. Measurement of Anaerobic Glycolysis in Brain as Related to Poliomyelitis. *J. Exper. Med.* 82: 217-226 (Sept.) 1945.

275 Foley, G. E., and Aycock, W. L. Alterations in Autarceologic Susceptibility of Mouse to Experimental Poliomyelitis by Estrogenic Substances. *Endocrinology* 37: 245-251 (Oct.) 1945.

276 Toomey, J. A., and Takacs, W. S. Effect of Cationic Detergents in Cotton Rats. Neutralizing Effect of Cetamium Against Poliomyelitis Virus. *Arch. Pediat.* 62: 337-339 (Aug.) 1945.

277 Wold, H. Statistical Note on Swedish Epidemics. *Acta med. Scandinav.* 115: 560-567, 1943.

outside, e. g. by infected food, (l) the epidemics spread by contagion and (c) the epidemics caused by variations in the number of susceptible persons. Theoretic results are directly compared with results of statistical observations made by Peterson. Curves are obtained for each type of epidemic. The records of poliomyelitis are investigated from countries in various parts of the globe. It is concluded that as the latitude increases the dispersion of the frequency curve—calculated as an average from several epidemics in the same district—decreases in proportion to the decrease of radiation from the sun. Wold made a similar study of epidemics of poliomyelitis, but his results do not agree with those of the other investigator. In summing up his observations, he states that the districts with low latitude have large populations, citing Australia, Mississippi and New York as extremes, while Iceland and Greenland, with their small populations, occupy the other end of the table. Thus, if the dispersion of the frequency curve tends to be larger and larger in more populous districts, this tendency is sufficient to explain at least a part of the correlation on which the law of latitude is based. This remark is not thought decisive as to the validity of the law of latitude but it is safe to say that a special investigation of the possible effects of such factors as the size and the density in population of the district must be made before the law of latitude can be regarded as definitely established.

Peterson²⁷⁸ redefines some of the statements previously made concerning the variation with latitude and epidemic curves. Epidemics in various parts of the world were studied. The article is also a rebuttal to the findings of Wold, who made similar studies of epidemics of poliomyelitis in Sweden. Peterson reemphasizes that the said regularity appears distinctly only for small variations in latitude when mean values for several epidemics from the same latitude are available owing to the fact that the individual epidemics may occasionally exhibit variations.

Bowerman²⁷⁹ states that poliomyelitis seems to occur during the summer months when hay fever is rife. The author has written a most interesting article correlating temperature and rainfall with the incidence of poliomyelitis. Studies were made in the area of New York city. A number of carefully prepared tables have been made showing the number of cases occurring in New York between the years 1907 and 1929. It is pointed out that during the years 1916, 1931 and 1935 the number of cases of poliomyelitis was much higher. During the same years there were longer periods of dryness and increased temperature.

This interesting article may be summarized as follows: 1. Dry warm summers seem to be frequently associated with outbreaks of polio-

278 Peterson, H. Variation with Latitude of Steepness of Epidemic Curves. *Acta med Scandinav* 117:24-28, 1944.

279 Bowerman, W. G. Statistical Survey of Influence of Weather on Incidence. *Arch Pediat* 62:57-77 (Feb) 1945.

myelitis in New York city. 2 The absence of rain seems more significant in this than changes in the mean temperatures. 3 The case fatality rate (ratio of death to cases) of poliomyelitis in New York city has frequently been in accord with the cycle of numbers of sun spots.

According to Dauer,²⁸⁰ during the year 1944 there were 19,053 cases of poliomyelitis reported in the United States, this figure having been exceeded once in the past, when 27,363 cases were reported in 1916. The incidence was highest in the following states: New York, Delaware, Kentucky, Virginia, North Carolina, Minnesota and Maryland. The most extensive and intensive outbreak occurred in a solid block of counties in western and southern New York state and in a single tier of counties in northern Pennsylvania bordering on New York. The western part of Massachusetts should also be included as a part of this outbreak. One third of all the cases reported in the United States in 1944 occurred in this area. In certain respects the distribution of poliomyelitis in 1944 was similar to that of the epidemic of 1935 as concerns states involved.

Poliomyelitis occurred in the armed forces of the United States in proportion to the prevalence in the civilian population of similar ages. The Army incidence was 3.4 per hundred thousand troops in 1943 and 4.0 in 1944. The occurrence of poliomyelitis in large cities has been striking during the past two years. There has been no regular occurrence or periodicity of outbreaks of poliomyelitis in cities of the United States during the past three decades and there has been no consistent interval of time between years of high incidence.

Smith and his co-workers²⁸¹ studied the 1944 epidemic in the Buffalo, N. Y., area. The cases which they observed did not arise *de novo* but were late developments in an existing cycle which were not suspected for three months. There was an interval of five and a half months between the last cases of the preceding year and the first case of 1944. Actually the interval was only two months, and the virus was probably active throughout the entire period between cycles. The number of cases of illness highly suggestive of poliomyelitis was five times the number of recognized cases. The evidence indicates that this Buffalo epidemic was initiated and spread largely through direct human sources.

Young²⁸² presents a most interesting report on 114 cases of poliomyelitis observed at the Children's Hospital of Texas, in Dallas, during 1943. Careful note is made of the age incidence, time distribution

280 Dauer, C. C. Incidence of Poliomyelitis in the United States in 1944. *Pub. Health Rep.* **60**: 633-642 (June 8) 1945.

281 Smith, M. L., Bridge, F. M., Underwood, H. E. and Dale, G. E. Study of Origin of Epidemic of Poliomyelitis. *J. A. M. A.* **129**: 1150-1156 (Dec. 22) 1945.

282 Young, J. G. Poliomyelitis. Report of Cases Seen in Dallas in 1943. *Texas State J. Med.* **40**: 527-530 (Feb.) 1945.

presenting symptoms, family incidence and type of involvement Ten per cent of the patients studied died, all with the bulbar type, 48 per cent were dismissed without further treatment, returning at a later date for a check on physical therapy, 14 per cent were to have head and exercise therapy at home when dismissed, and 28 per cent were admitted to the orthopedic hospital for further treatment

In the cases of bulbar involvement the first symptom was usually difficulty with speech In addition, facial paralysis, all on the left side, and paralysis of the ocular muscles were noted All patients having facial paralysis, however, had a bulbar type of poliomyelitis The concept as to the duration of active continuing spread of the disease within the nervous system being limited to five or six days was disproved Frequent thorough testing of the patients showed spread for as long as twelve days Management of the patients during the acute stages was according to the Kenny method It was believed that the treatment prevented contractures, lessened muscle spasm and materially shortened time for recovery In line with recent experimental evidence concerning the theory that the pathologic basis of muscle spasm depends on a lesion of the internuncial neurons is discussed

Bohls and Irons²⁸³ report that following an unusually late fall and early winter period of increased prevalence and a quiescent period an outbreak of poliomyelitis unprecedented in the history of Texas occurred during the summer of 1943 The 1943 morbidity rate for the state as a whole was approximately 20 per hundred thousand and, although low in comparison with some of the state's more pressing problems of communicable disease, was nearly ten times the morbidity rate for poliomyelitis in more recent years

The mode of transmission was not determined, but it was believed that unrecognized infections and large numbers of temporary carriers were contributory factors of great importance The possible role of flies and other insects or arthropods as vectors of the infection was not determined Some laboratory findings were discussed Laboratory observations concerned neutralization tests with serum-virus mixtures and the attempted recovery of poliomyelitis or poliomyelitis-like virus from various sources

McLendon and his associates²⁸⁴ discuss the epidemic of 1944 Two hundred and five patients were treated at the Children's Hospital This number represented 66 per cent of the total cases reported Males predominated in number, the peak of the epidemic was reached in

283 Bohls S W, and Irons, J V Report on 1943 Outbreak of Poliomyelitis Texas State J Med 40 412-417 (Dec) 1944

284 McLendon, P A Wall, J S Anderson W S Hand F M, and Todd R H 1944 Poliomyelitis Epidemic Analysis of Cases Seen at Children's Hospital Washington, D C, M Ann District of Columbia 14 287 293 (July) 1945

August and the greatest number of cases occurred in the age group of 7 to 13 years

The commonest symptoms were fever, headache, pain in the muscles, weakness of the muscles and paralysis and stiff neck. Of the 205 patients, 38 had bulbar poliomyelitis, of these, 6 died, these being the only deaths in the total number. This represents an over-all mortality rate of 2.9 per cent.

Fifty-four patients of the total had nonparalytic poliomyelitis. They received routine care and were dismissed. One hundred and fourteen patients with the spinal paralytic type were admitted, and it was this group which offered the biggest problem.

Of the 205 patients admitted, the authors followed 162 for nearly a year. Of these, 70 per cent are entirely well, 18 per cent have residual paralysis and about 11 per cent have poor function. After these patients have been followed another year it is hoped that 80 per cent will show a normal recovery, and the number with residual paralysis will constitute about 20 per cent.

Anderson²⁸⁵ presents statistics gathered from the 1943 epidemic in Utah. In 89 per cent of the cases the condition occurred in persons under 20 years of age. Questionnaires were sent to three hundred and thirty-four physicians in the state. Eighty-one per cent of the physicians returned the questionnaires. During July, August and September four thousand, one hundred and ninety-nine tonsillectomies were done, and statistics were based on this group. The results were as follows: 1. In 43 per cent of the cases of bulbar and bulbospondyl poliomyelitis tonsillectomy had been performed within thirty days prior to the initial symptoms. 2. The incidence of poliomyelitis in children who had recently had tonsillectomy was two and six-tenths times greater than that in the general child population. 3. The incidence of the bulbar and bulbospondyl type of poliomyelitis was found to be sixteen times greater in children who had recently had their tonsils removed than in the general child population.

Wyllie²⁸⁶ points out the infrequency of second attacks of poliomyelitis and presents a case from his own observation. He reviews a total of 19 cases in which it has been confirmed that second attacks of the disease have occurred. The interval varied from two to twenty-five years.

Casey and his associates²⁸⁷ have observed that multiple cases of poliomyelitis in the family are the rule rather than the exception when

285 Anderson, J. A. Poliomyelitis and Recent Tonsillectomy, *J. Pediat.* **27** 68-70 (July) 1945.

286 Wyllie, J. Second Attack of Poliomyelitis After Thirteen Years. *Canad. J. Pub. Health* **36** 156-159 (April) 1945.

287 Casey, A. E., Fishbein, W. I. and Bundesen, H. N. Transmission of Poliomyelitis by Patient to Patient Contact, *J. A. M. A.* **129** 1141-1145 (Dec 22) 1945.

there are children from $1\frac{1}{2}$ to $8\frac{1}{2}$ years of age in the home. It is their opinion that poliomyelitis is contagious perhaps to the degree of 90 per cent in the age groups of $1\frac{1}{2}$ to $3\frac{1}{2}$ years but less infectious in the older groups. They found no evidence that flies or other insects play a major role in transmission once the disease has been introduced. In only $1\frac{1}{2}$ cases out of 6 was a diagnosis of poliomyelitis made even with an alert reporting system. Physicians were not even consulted in many cases. Paralysis was observed in 1 case out of 6.

Brown and his co-workers²⁸⁸ studied a group of 7 campers, in 1 of whom poliomyelitis developed five days after his arrival at camp. Cultures of stools were taken at intervals on his cabin mates. These were positive for the virus in 5 of the boys dating from five days after the onset of the disease. The second case of poliomyelitis occurred nineteen days after the virus was first found in the stools.

It has been proved that the poliomyelitis virus can be carried by flies to food. Various experiments have also proved that this virus enters the alimentary canal, probably multiplies there and reaches the central nervous system indirectly. Ward and his associates,²⁸⁹ through experimentation have made this observation that food exposed to flies in the homes of patients with poliomyelitis in an epidemic area may acquire a quantity of poliomyelitis virus sufficient to produce in chimpanzees by oral administration a nonparalytic infection or an asymptomatic carrier state.

Casey²⁹⁰ makes a detailed report on the epidemic of poliomyelitis occurring in Walker County, Ala., during the summer and autumn of 1941. One hundred and twenty-one cases were reported in the county. Most of the cases could be traced directly or indirectly to one focus at Barnev, Ala. The author found during a study of the cases that the incubation period from the day of exposure to the onset of the prodromal period averaged twelve days. The infectious period was between three days before and three days after the onset of the prodromal period. Evidence of patient to patient contact was found in 80 per cent of the cases studied. Contacts were almost entirely among children under 15 years of age and largely among those under 4 years of age. When the average air line distances of the places of contact for each twelve day period of the epidemic were calculated there was evidence

288 Brown, G. C., Francis, T. Jr. and Pearson, H. E. Rapid Development of Carrier State and Detection of Virus in Stool Nineteen Days Before Onset of Paralytic Disease. *J. A. M. A.* **129**: 121-123 (Sept. 8) 1945.

289 Ward, R., Melnick, J. L. and Horstmann, D. M. Poliomyelitis Virus in Fly-Contaminated Food Collected at an Epidemic. *Internat. M. Digest* **47**: 55-58 (July) 1945.

290 Casey, A. E. Place of Contact and Radial Spread of Epidemic Poliomyelitis. *Am. J. Dis. Child* **69**: 152-156 (March) 1945.

of orderly radial spread at the rate of about 1 mile (1.6 Km) for each ten or eleven days, or an average of 8.7 miles (13.9 Km) in the ninety-six days of the epidemic.

Conclusions as to contacts with healthy persons and with adults, drinking water, flies, mosquitoes, rodents and other vectors did not seem to have much importance. There was the possibility that sewage-polluted waters concentrated by a severe drought explained many sporadic cases, many cases of the disease in adults, and perhaps the original case from which the epidemic started. It was questioned whether the incidence of poliomyelitis in the summer is not dependent usually on the concentration of sewage-polluted streams and waters by drought and heat in areas where there are sufficiently large infant populations and numerous prolonged contacts among adults.

Because flies have been proved to be carriers of poliomyelitis virus during epidemics of the disease, Power and Melnick²⁹¹ made a systematic study of the fly population of New Haven, Conn., during the summers of 1942, 1943 and 1944, 1943 was an epidemic year, while 1942 and 1944 were not.

The observations were as follows: 1. The peak of the fly population curve preceded the 1943 poliomyelitis epidemic, with the centers of the two pyramids being separated by about four to five weeks. 2. During the height of the 1943 epidemic there were only four genera of flies present in the trapped population, and they were commoner during and preceding the epidemic than at any time during the three years of the study. 3. It is unknown if the characteristics of the 1943 fly population had any epidemiologic correlation with the poliomyelitis epidemic of that year.

Complications and Sequelae—After the publication of Buchthal and Clemmessen in 1943 concerning the synchronous activities of the different motor units of the muscle, Buchthal and Honcke²⁹² decided to investigate how early in the course of the disease the abnormal mode of enervation occurred in poliomyelitis. It has been known since their publication that electromyography could be employed for the differentiating of various types of muscle atrophy. They showed that myogenic atrophy is accompanied with normal electrical activity, while in cases of neurogenic atrophy the electromyogram indicated a reduction of the number of motor units by the occurrence of active potentials from single motor units without the interference from neighboring fibers, even during

291 Power, M. E., and Melnick, J. L. Three-Year Survey of Fly Population in New Haven During Epidemic and Non-Epidemic Years for Poliomyelitis. *Yale J. Biol. & Med.* **18**: 55-69 (Oct.) 1945.

292 Buchthal, F. and Honcke, P. Electromyographic Examination of Patients up to Six Months After Acute State of Disease, *Acta med. Scandinav.* **116**: 148 1944.

attempts at maximum enervation. In connection with poliomyelitis, it is of special interest that there is a difference in the enervation between myogenic atrophy and peripheral or radicular origin and atrophy caused by certain intermediate diseases.

In 21 of 47 cases of acute poliomyelitis the development of the pareses and their restitution were followed electromyographically by the authors. Generally, neither the acute phase nor the later stages of the disease showed spontaneous activity in relaxed muscles. The synchronous activity recently found in apparently intact motor units (stationary parietic muscles after poliomyelitis) was in some cases observed during the acute phase of the disease. They noted that synchronization may appear extremely early after the pareses have set in and is presumably caused by irradiation of impulses over a large range of ganglionic cells (facilitation of spatial summation).

A comparison of different types of enervation (synchronous, partly synchronous and asynchronous activity) evidenced from the electromyogram with the clinical course of the pareses indicates that the chances of restitution are more favorable in cases of continuous asynchronous activity and less so when synchronous activity is lasting. Further electromyographic examination revealed that paresis may progress for some time after the febrile stage and that restitution of the parietic muscle may in any case continue up to six months.

Conte and his co-workers²⁹³ report 2 cases of pseudohypertrophic muscular dystrophy, with two purposes in mind: first, to review the disease entity pseudohypertrophic muscular dystrophy, with particular reference to the endeavors being made to establish a satisfactory method of treatment, and second, to present a report of 2 patients with this disease who contracted poliomyelitis during recent epidemics.

The first child, 8 years old, was admitted to the hospital in August 1944, following the onset of stiffness of the neck and headache. After clinical and laboratory studies a diagnosis of poliomyelitis was made and treatment with hot packs instituted. Improvement was satisfactory, and the child was discharged from the hospital a month later with no complications. The second patient was admitted to the hospital in 1944, with a high temperature, vomiting and pain in both legs and feet and in the region of the umbilicus. The onset occurred two days previously. Striking involvement of the muscles affecting respiration made it necessary to place the patient in a respirator, where he remained for twenty-six days. Hot packs and supportive measures were used. Decided weakness of the lower extremities persisted. The patient was still hospitalized in December 1944 with considerable residual manifestations. It will be

293 Conte, A. N., Dettweiler, H. J., and Madigan, H. S. Pseudo Hypertrophic Muscular Dystrophy. Two Cases Developing Poliomyelitis. *Arch. Pediat.* 62:4-15 (Jan.) 1945.

of interest to observe the course of the muscular dystrophy following acute phases of poliomyelitis. One of the patients had regained the status prior to contracting poliomyelitis at the time of publication.

Metheny and Olson²⁹⁴ point out that surgical procedures are sometimes necessary on patients with poliomyelitis. Such intervention is more complicated when the patient is in a respirator. The authors could not find a previous record of a case in which an appendectomy had been done on a patient with respiratory paralysis.

The authors present a case of poliomyelitis in which a diagnosis of acute appendicitis was made while the patient was in the respirator. The patient was moved to the operating room in the respirator and anesthetized with nitrous oxide and a small amount of ether. Positive pressure was used in administration of the anesthetic. With everything in readiness, the patient was slid out of the respirator and the abdomen prepared and draped. The appendix was removed and artificial respiration was applied by alternate pressure on the chest and on the rebreathing bag. Fifteen minutes was spent out of the respirator. Following replacement, the patient regained consciousness satisfactorily.

Salem²⁹⁵ reports a case of almost symmetric primary dorsolumbar kyphosis due to anterior poliomyelitis. Pointing out the rarity of such a deformity, he reviews the course of the disease and attempts to explain the cause of the kyphosis.

The patient was seen one and one-half years after the acute onset of his disease, at which time the right lower extremity was diffusely involved and weakness was evident in the anterior abdominal muscles. The right side of the pelvis was tilted forward and down, so that the right anterior superior spine was 2 inches (5 cm) lower than the left, thereby producing an apparent lengthening of the right lower extremity. When the patient was standing, the trunk was held flexed at the hip, but there was no increased lumbar lordosis. A definite kyphosis with decided prominence of the lower dorsal and upper lumbar spinous processes was present. Despite the pelvic tilt, only a slight lower dorsolumbar scoliosis on the right side was evident.

There was a weak right quadriceps and a strong tensor fascia muscle. The left lateral abdominal muscles exhibited fair strength, with less strength on the right side. There was some weakness of the right quadratus lumborum muscle but no weakness of the iliopsoas muscle on either side. The pelvic obliquity disappeared on recumbency.

In attempting to make an etiologic diagnosis, the author suggests that the relative weakness of the extensor muscles of the trunk may have

294 Metheny, D. and Olson, H. H. Appendectomy on Poliomyelitis Patient in Drinker Respirator, *West J Surg* 53: 88-89 (March) 1945.

295 Salem, E. P. Dorsolumbar Kyphosis Due to Anterior Poliomyelitis. *Bull Hosp Joint Dis* 6: 53-60 (April) 1945.

been a factor. He cannot, however, offer a positive reason for the absence of scoliosis. The spine was fused (including the tenth dorsal through the third lumbar vertebrae), but a pseudoarthrosis was noted some six months later. Abdominal fascial reinforcements were also done. The author points out that the final result is still uncertain.

Surgey—Zausmer²⁹⁶ states the opinion that transplanted muscles must learn to perform a new function. The innervation of individual muscles is open to question, their action being part of a complex mechanism. In any event, reeducation relies on principles of function rather than that of mechanism. In reeducation the first consideration is passive and guided active exercise. Then active movement is an important factor. These exercises help account for proper innervation. Stretching is to be avoided in early reeducation. After the early stage, when strength is desired, resistive exercises may be used. These should be done slowly and with long periods of rest. The program of treatment as outlined is as follows: (1) production of basically correct working capacity of the transplanted muscle, without substitution and wrong habits; (2) increase in range of movement, passively and actively; (3) increase in strength and power; (4) development of speed of desired movement; and (5) full functional adaptation into integral movements.

Practical examples of transplantations of muscles (the peroneus longus muscle to the anterior tibial insertion and the biceps femoris muscle to the patella) and their functional reeducation are demonstrated.

In his paper Brown²⁹⁷ presents a technic of making a prosthesis which restores the contour of the lower limb, correcting the deformity caused by atrophy of the limb. The deformity is usually caused by poliomyelitis and is the result of atrophy of the muscles themselves. Other deformities are corrected by surgical treatment or appliance of other types, such as shoes, but even after the gait is normal the slender "broomstick" appearance of the affected limb attracts unfavorable attention. It is to correct the thinness of the limb that such a patient desires a prosthesis.

The technic is carefully described, and the advantages of this particular prosthesis are enumerated. These include its light weight, its comfort in wearing and its elasticity, which makes it easy to apply like a stocking. Another advantage is that the surface rebounds exactly the same way as does normal skin when it is pressed or indented with the finger.

296 Zausmer, E. Functional Reeducation of Transplanted Tendons, *Physiotherapy Rev.* **25** 160-164 (July-Aug.) 1945.

297 Brown, A. M. Correction of Poliomyelitis Deformities with Frothed Latex Prostheses, *J. Bone & Joint Surg.* **27** 513-517 (July) 1945.

XI INFANTILE PARALYSIS RESEARCH

Prepared by

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JANUARY-JUNE 1944

RESEARCHES on many fundamental questions concerning infantile paralysis continue to add little by little to existing knowledge of the disease. The various problems that beset the research worker have been presented by Gard²⁹⁸ in a monograph of one hundred and sixty-five pages which does not lend itself well to detailed review.

The Virus of Poliomyelitis—Loring and Schwerdt²⁹⁹ found that the MVA purified poliomyelitis strain was stable in solution as acid as p_H 1.6 but unstable below this figure and that it was stable in solution as alkaline as p_H 10.3 but unstable above this figure. Olitsky³⁰⁰ describes the properties of a virus discovered by Theiler and Card, which he considers not to be mouse poliomyelitis of either natural or experimental type. He states that the difference between it and other strains of mouse poliomyelitis virus is such as to make it entirely unsuitable as a model for the study of human poliomyelitis.

Toomey, Takacs and Tischer³⁰¹ were unable to demonstrate the presence of virus in the carp. With the methods and amounts used in these experiments they were unable to immunize these fish to the point of showing neutralizing antibodies and also were unable to demonstrate live virus in the contents of the stool.

Finlayson and Wicht³⁰² succeeded in transferring poliomyelitis virus to South African black-faced monkeys by means of intracerebral and intraperitoneal inoculations. Gordon³⁰³ demonstrated that muskrats can be infected by the Lansing strain of poliomyelitis when it is injected intracerebrally, and they succeeded in transmitting the infection through

298 Gard S. Purification of Poliomyelitis Viruses. Experiments on Murine and Human Strains, *Acta med Scandinav* 1943 supp 143 pp 1-173.

299 Loring, H S and Schwerdt C E. Studies on Purification of Poliomyelitis Virus. p_H Stability Range of MVA Strain, *Proc. Soc Exper Biol & Med* 57 173-175 (Nov.) 1944.

300 Olitsky, P K. Certain Properties of Theiler's Virus Especially in Relation to Its Use as Model for Poliomyelitis. *Proc Soc Exper Biol & Med* 58 77-81 (Jan.) 1945.

301 Toomey J A, Takacs W S, and Tischer L A. Attempts to Find Poliomyelitis Virus in Fish, *Proc. Soc Exper Biol & Med* 58 152-154 (Feb.) 1945.

302 Finlayson M H and Wicht, J F. Investigation of Cases of Suspected Poliomyelitis with Special Reference to Susceptibility of *Lasiopygus* (*Cercopithecus*) *Pygerythrus* (South African Black-Face Monkey) to Virus, *South African M J* 19 101-103 (March 24) 1945.

303 Gordon, F B. Susceptibility of Muskrats and Other Rodents to Poliomyelitis Virus (Lansing Strain). *J Infect. Dis* 76 155-162 (March-April) 1945.

four generations. They found white-footed mice irregularly infected and ground squirrels entirely refractory.

Melnick³⁰⁴ reports that of 10 monkeys paralyzed after being inoculated with poliomyelitis virus of recent human origin 3 rhesus and 1 capuchin monkey were found to have the virus in the bloodstream. All the positive results given by tests of the blood were due to a single strain. The contents of the colon of 3 of these 4 monkeys were examined for virus, it was found in only one instance. Of 4 monkeys in whose blood virus could not be detected, 1 was found to have virus in the contents of its colon.

Jungeblut³⁰⁵ describes unsuccessful attempts to separate by processes of physical segregation, i. e., ultrafiltration, ultracentrifugation and dialysis, from live SK murine poliomyelitis virus a nonpathogenic agent capable of interfering with simian poliomyelitis virus. He was also unable to convert live SK murine virus into a nonpathogenic interfering agent by processes of chemical inactivation, i. e. phenolization and formalinization. Preparations of SK murine virus which had been greatly attenuated by ultraviolet irradiation gave evidence of having retained some interfering power in rhesus monkeys. MM murine poliomyelitis virus interfered both in mixture tests and by peripheral administration with two simian strains of poliomyelitis virus. Distinct protective effects were observed in rhesus monkeys which had received adequate amounts of murine virus (animal passage or tissue culture virus) up to forty-eight hours after intracerebral infection with simian poliomyelitis virus. Theiler's virus of spontaneous mouse encephalomyelitis when tested in mixture with simian poliomyelitis virus gave some evidence of irregular and low grade interference. Interference could not be shown conclusively in experiments to prevent poliomyelitic infection or to modify its effects. The author discusses the nature of the interfering agent in murine virus.

Brown and Francis³⁰⁶ present evidence that the serum of mice paralyzed with the Lansing strain of poliomyelitis virus possesses the capacity of protecting normal mice against the same virus when mixtures of virus and serum are inoculated intracerebrally. The virus-neutralizing action was present mainly in mice paralyzed between the third and sixth days following inoculation and was rarely demonstrable in the serum of mice in which paralysis developed more than ten days

304 Melnick, J. L. Poliomyelitis Virus in the Blood Stream in Experimental Disease, *Proc Soc Exper Biol & Med* **58** 14-16 (Jan) 1945

305 Jungeblut, C. W. Studies in Rodent Poliomyelitis. Further Observations on Interference Between Murine and Simian Strains of Poliomyelitis Virus. *J Exper Med* **81** 275-294 (March) 1945

306 Brown, G. C., and Francis, T., Jr. Virus-Neutralizing Action of Serum from Mice Infected with Virus. *J Exper Med* **81** 161-169 (Feb) 1945

after inoculation. Serum from nonparalyzed mice had approximately equal neutralizing capacity when obtained during the same period following inoculation as that during which serum from paralyzed mice showed the greatest effect. Neutralization of the virus was not obtained with serum from normal mice or from mice inoculated with normal nervous tissue.

Howe and Bodian³⁰⁷ inoculated 6 chimpanzees orally with stool from a patient with poliomyelitis. Three of the animals had been given 170 cc of homologous hyperimmune monkey serum prior to inoculation, while 3 were unprotected. All the animals were subsequently shown to have poliomyelitis virus in their stools and characteristic lesions in their central nervous systems, although paralysis developed in none of them. All the immunized animals had demonstrable blood antibody at the time of inoculation, although thirty days later it was present in only 1 animal.

Epidemiology — Finlayson³⁰⁸ reviews recent conceptions of how virus enters the human system. He expresses the opinion that the evidence suggests that in human beings the gastrointestinal tract and pharynx are the main routes of infection. Ward, Melnick and Horstmann³⁰⁹ state the theory that food exposed to flies in the homes of patients with poliomyelitis in an epidemic area may become contaminated to such an extent that the disease can be reproduced when the contaminated material is fed to chimpanzees.

In an article published in 1942 but not previously available for review, Kling, Olin, Fahraeus and Norlin³¹⁰ record the demonstration of virus in sewage water; they express the opinion that this is an important factor in transmission. The authors state that American scientists were slow to believe that the gastrointestinal tract is an important portal for infantile paralysis.

[ED. NOTE — This editor has given ample clinical proof for at least twenty-five years that the gastrointestinal tract is a route of infection.]

307 Howe, H. A., and Bodian, D. Passive Immunity to Poliomyelitis in Chimpanzee, *J. Exper. Med.* **81** 247-254 (March) 1945.

308 Finlayson, M. H. Recent Research on Poliomyelitis, *Clin. Proc.* **3** 481-485 (Dec.) 1944.

309 Ward, R., Melnick, J. L., and Horstmann, D. M. Poliomyelitis Virus in Fly-Contaminated Food Collected at an Epidemic, *Science* **101** 491-493 (May 11) 1945.

310 Kling, C., Olin, G., Fahraeus, J., and Norlin, G. Sewage as Carrier and Disseminator of Poliomyelitis Virus. Searching for Poliomyelitis Virus in Stockholm Sewage. *Acta med. Scandinav.* **112** 217-249 1942, Sewage as Carrier and Disseminator of Poliomyelitis Virus. Studies on Conditions of Life of Poliomyelitis Virus Outside Human Organism. *ibid.* **112** 250-263 1942.

In a second article on sewage as a carrier and disseminator of virus, Kling and his associates record the finding that virus can remain infective in sewage for at least two months at a temperature of 4 C. They draw attention to a protozoan belonging to the genus *Bodo* as a possible vector.

The effectiveness of chlorine as a disinfecting agent of poliomyelitis has been investigated by Trask, Melnick and Wenner³¹¹. A residual chlorine level of 0.4 part per million after ten minutes did not inactivate the CR strain (10^{-2}), and 0.5 part per million was insufficient to destroy the SK strain (10^{-3}). The virus in a 10 per cent centrifuged suspension of stool from a patient with poliomyelitis withstood a dose of chlorine of 120 parts per million, leaving a residual value of 15 parts per million after ten minutes of contact. The authors report comparable results with Theiler's mouse virus. When extraneous organic tissue was present, more chlorine had to be used to meet an additional demand.

[ED. NOTE —The authors did not appear to be impressed with the value of chlorine as a disinfecting agent for poliomyelitis.]

Howe, Bodian and Wenner³¹² have demonstrated poliomyelitis virus in pharyngeal swabs taken from patients ill with the spinal and bulbar paralytic forms as well as those with the nonparalytic form. Virus was found to be present in 43 per cent of a series of 23 patients from whom swabs were taken during the first three days of illness. In no instance was virus found after the third day.

Rosenow³¹³ claims that an alpha streptococcus is constantly present in the nasopharynx and commonly in the blood of patients who have had poliomyelitis. He describes a cutaneous test, a precipitation test, a poliomyelitis streptococcus antiserum and the production of the experimental disease.

[ED. NOTE —The experiments of Rosenow are difficult to follow, particularly by one who, like this editor, has not repeated his work.]

Kessel and Moore³¹⁴ investigated the occurrence of virus in the tonsils and stools of noncontacts. In a survey involving 136 persons who had had no known contact with clinical poliomyelitis and from whom

311 Trask, J. D., Melnick, J. L. and Wenner, H. A. Chlorination of Human, Monkey-Adapted and Mouse Strains of Poliomyelitis Virus, *Am J Hyg* **41** 30-40 (Jan.) 1945.

312 Howe, H. A., Bodian, D., and Wenner, H. A. Further Observations on Presence of Poliomyelitis Virus in Human Oropharynx. *Bull Johns Hopkins Hosp* **76** 19-24 (Jan.) 1945.

313 Rosenow, E. C. Further Studies on Specific Streptococcal Antibody Antigen Reactions in Poliomyelitis. *Am J Clin Path* **15** 135-151 (April) 1945.

314 Kessel, J. F., and Moore, F. J. Occurrence of Poliomyelitis Virus in Tonsils and Stools of Noncontacts During Interepidemic Period, *Am J Hyg* **41** 25-29 (Jan.) 1945.

both tonsils and stools pooled in groups of three each were tested, poliomyelitis virus was recovered from three pools of tonsils and three pools of stools. Since one of these pools of tonsils and one pool of stools was from the same group of 3 persons, it may be concluded that at least 5 of the 136 persons harbored virus either in their tonsils or in their stools. The survey was performed during an interepidemic period all but one of the positive results were obtained during the last three months of this period this one having been encountered during the first month of a major outbreak.

[ED NOTE—The inference that persons who have tonsils removed in interepidemic times are taking grave chances is not borne out by statistics. The authors do not indicate what happened to the person who had a tonsillectomy with virus present. It was curious that they could not transfer their isolated viruses subsequently to animals of the same species.]

Seasonal variations in susceptibility have been investigated by Jungeblut³¹⁵. Serial propagation ofavian poliomyelitis from guinea pig to guinea pig was not significantly influenced by seasonal fluctuation of any sort. However, the transmission of murine poliomyelitis virus from mouse to guinea pig functioned more effectively in the winter than in the summer as judged by the ratio between paralyzed and nonparalyzed animals. The described phenomenon appears to be due preponderantly to cyclic variations in the susceptibility of the guinea pig to the paralyzing effect of the virus when passed by intracerebral injection from one host to another.

Pathology—Elliott³¹⁶ found that in the motor nuclei of the region of the limbs all lesions first involved the dorsal and medial nuclei, appearing to arise from a single focus. Most important is the fact that destruction of motor cells may be present in the absence of recognizable paralysis.

Bodian and Howe³¹⁷ studied the pathologic changes in 13 cases of nonparalytic poliomyelitic infection in chimpanzees. Nine animals excreted virus in their stools at periods of from three days to eight weeks following inoculation. All animals killed during the acute stage showed lesions in the brain distributed in centers usually involved in and compatible with the presence of poliomyelitic infection. In 2

315 Jungeblut C W. Seasonal Fluctuations in Susceptibility of Guinea Pigs to Experimental Avian Poliomyelitis. *Proc Soc Exper Biol & Med* **58** 177-180 (Feb) 1945.

316 Elliott H C. Studies on Motor Cells of Spinal Cord. Position and Extent of Lesions in Nuclear Pattern of Convalescent and Chronic Poliomyelitis Patients. *Am J Path* **21** 87-97 (Jan) 1945.

317 Bodian D and Howe H A. Nonparalytic Poliomyelitis in Chimpanzee. *J Exper Med* **81** 255 (March) 1945.

chimpanzees typical lesions of the cord were also present. No lesions were found in the brains of 4 control chimpanzees which had had no contact with virus. The occurrence of a purely systemic or peripheral form of poliomyelitis, without lesions in the central nervous system, has thus not been established. Four instances of arrest of the pathologic process near the portal of entry into the brain, indicating partial resistance, are included in this series. Although cerebral lesions were mild in some of the nonparalytic and inapparent infections, their presence in all indicates the action of virus on the central nervous system with the possibility of production of at least a partial local resistance. "It is not unreasonable to assume that this may occur in cases of conditions inapparent in human beings, although this point is not of course, susceptible to critical proof in human beings." The severity of the pathologic involvement in nonparalytic patients varies from a full developed distribution of lesions in the brain and spinal cord in some chimpanzees to mild and scattered lesions in the brains of others. This suggests that, if the extent of the pathologic reaction is an indicator of subsequent local resistance to reinfection, the degree of protection afforded by a nonparalytic attack of poliomyelitis to even homologous virus must be variable. In another paper, Bodian and Howe³¹⁸ make the point that the pathologic diagnosis of poliomyelitis can be made only by the observation of typical parenchymal lesions in the cord, including neuronal necrosis, neuronophagia and focal and perivascular infiltration, or by the observation of similar infiltrative lesions distributed in characteristic fashion in the brain. Such findings are more reliable than clinical criteria, since many infections are clinically inapparent.

[ED NOTE—The clinical picture and the pathologic findings are in no wise parallel in the rhesus monkey, and the clinical picture may give us no definite clue as to what happens in the central nervous system of human beings. This was shown by Toomey and Lipson in 1926.]

Ibanez³¹⁹ has written a monograph on changes in the peripheral portion of nerves in the muscles of patients with poliomyelitis.

[ED NOTE—American readers are not unfamiliar with these reactions which have been demonstrated by Carev.]

Watkins and Brazier³²⁰ describe quantitative studies of innervation

318 Bodian, D., and Howe, H. A. Experimental Nonparalytic Poliomyelitis. Frequency and Range of Pathologic Involvement, *Bull. Johns Hopkins Hosp.* 76: 1-17 (Jan.) 1945.

319 Ibanez, J. S. Experimental and Biopsy Study of Mononeural Sympathy of Paralytic Human Muscles, *Cir. d. ap. locom.* 1: 193-201 (July) 1944.

320 Watkins, A. L., and Brazier, M. A. B. Studies on Muscle Innervation in Poliomyelitis and Nerve Injury, *Arch. Phys. Med.* 26: 69-75 (Feb.) 1945.

of muscles, mentioning the ergograph, voltage capacity, curves of electrical excitability, electromyograms of action potentials and spontaneous electrical discharges from resting muscles. They state that the application of these methods reveals a recovery process in the motor unit in poliomyelitis.

[ED NOTE—Although presenting nothing new, this article should be worth while for physicians who are interested in the quantitative innervation of muscles.]

Therapy—Studying the influence of thiamine deficiency on the susceptibility of *Macaca mulatta* to experimental poliomyelitis Clark, Waisman, Lichstein and Jones³²¹ found that this species when deficient in thiamine does not exhibit an increased resistance to poliomyelitis virus. This is in contrast to the well demonstrated resistance of Swiss mice similarly fed. Weaver,³²² experimenting with cotton rats comes to the conclusion that there is no evidence to support the theory that the virus of poliomyelitis is a biochemical by-product of vitamin B₁ deficiency or that poliomyelitis is a fulminating form of beriberi. McGarrahan³²³ has discussed possible etiologic and therapeutic relationships between chickenpox, herpes zoster and poliomyelitis.

Sampson³²⁴ states the belief that anoxia of the spinal cord may exist in poliomyelitis and that if nerve cells cannot utilize oxygen in the absence of glucose there may be some point in administering dextrose intravenously and in giving oxygen.

[ED NOTE—The author presents no facts to confirm his beliefs.]

Wood, Rusoff and Reiner³²⁵ were unable to confirm the report of Kabat and others that anaerobic glycolysis of the brain is impaired in poliomyelitis.

It has been shown that when a nerve to a paretic muscle is crushed new fibers are given off from such as remain viable. With this as a background, Billig³²⁶ has devised an operation for axonal interruption which he terms "neurotripsy." This procedure may be opened or closed in type.

321 Clark, P. F., Waisman, H. A., Lichstein, H. C. and Jones, E. S. Influence of Thiamine Deficiency in *Macaca Mulatta* on Susceptibility to Experimental Poliomyelitis. *Proc. Soc. Exper. Biol. & Med.* **58** 42-45 (Jan.) 1945.

322 Weaver, H. M. Resistance of Cotton Rats to Virus of Poliomyelitis as Affected by Intake of Vitamin B Complex, Partial Inanition and Sex. *Am. J. Dis. Child.* **69** 26-32 (Jan.) 1945.

323 McGarrahan, J. C. Chickenpox, Herpes Zoster and Acute Anterior Poliomyelitis. *New York State J. Med.* **45** 193-195 (Jan. 15) 1945.

324 Sampson, B. F. Suggested New Treatment of Poliomyelitis. *South African M. J.* **18** 421 (Dec. 23) 1944.

325 Wood, H. G., Rusoff, I. I. and Reiner, I. M. Anaerobic Glycolysis of Brain in Experimental Poliomyelitis. *J. Exper. Med.* **81** 151-159 (Feb.) 1945.

326 Billig, H. E., Jr. Muscle Reinnervation. *I. Internat. Coll. Surgeons* **7** 457-461 (Nov.-Dec.) 1944.

[ED NOTE—Only time can tell whether this reaction is of value. At this writing the statistical reports are confusing.]

JULY-DECEMBER 1945

Sabin³²⁷ reviews his previous articles on the natural history of poliomyelitis.

Coole^{327a} suggests that poliomyelitis, influenza and the common cold have identical causation, viz., a specific pleomorphic, short chain streptococci, existing only *in vivo* when it becomes virus in form and virulent in character. The micro-organism usually remains as a microscopic short chain streptococcus when quiescent in the upper respiratory tract. In a second paper by the author, entitled "A Concept of the Etiology and Control of Polio and Its Complication—Infantile Paralysis" penicillin and sulfonamide derivatives are recommended.

[ED NOTE—Penicillin is totally worthless in treating this disease and, as Toomey,³²⁸ as well as Rosenow, has demonstrated, the use of sulfonamide drugs aggravates the neurotropic condition in the monkey. Toomey has had human patients in whom he felt the use of the drug might have been harmful.]

Levinson and associates³²⁹ experimented with the effects of exercise and chilling in experimental poliomyelitis in human beings, and their conclusions were as follows: 1. In monkeys subjected to exhausting exercise during the incubation period of experimental poliomyelitis a higher incidence and severer paralysis developed than in controls. 2. In monkeys subjected to chilling during the incubation period of experimental poliomyelitis there developed also a higher incidence and severer paralysis than in controls. 3. Trauma of one or more limbs during the incubation period of experimental poliomyelitis in monkeys showed no correlation with location of paralysis, and the severity or extent of paralysis did not differ from that of the controls. 4. The incidence and severity of paralysis was significantly greater in monkeys inoculated with poliomyelitis virus during the summer months.

One wonders about the effect of chilling, since the disease is so frequently present in epidemic form during the dog days, when the tem-

327 Sabin, A. B. Studies on the Natural History of Poliomyelitis. *Cincinnati J. Med.* **26**: 417-445 (Nov.) 1945.

327a Coole, W. A. A Concept of the Etiology and Control of Polio and Its Complication—Infantile Paralysis. *Texas State J. Med.* **41**: 203-207 (Aug.) 1945.

328 Toomey, J. A. (a) Accelerated Production of Poliomyelitis. *Proc. Soc. Exper. Biol. & Med.* **31**: 1015-1017 (May) 1934. (b) Poliomyelitis Antiserum. *ibid.* **32**: 1346-1348 (May) 1935. (c) Poliomyelitis Serum Obtained from Horse. *Am. J. Dis. Child.* **53**: 1492-1502 (June) 1937. (d) Poliomyelitis Antiserum Obtained from Horses. I. Neutralizing Effect Against Various Strains of Virus. *ibid.* **55**: 1261-1266 (June) 1938.

329 Levinson, S. O., Milzer, A. and Lewin, P. Effect of Fatigue, Chilling and Mechanical Trauma on Resistance to Experimental Poliomyelitis. *Am. J. Hyg.* **42**: 204-213 (Sept.) 1945.

perature may be uncomfortably high and the possibility of chilling so minimal

Kendall³³⁰ wrote about the contagiousness of poliomyelitis. He has made several points with which I agree. He theorizes that the virus is widespread and that the disease is usually mild and clinically unrecognizable and spread by carriers—by patients with mild, atypical, abortive conditions in which diagnosis has been missed—and by virus from the nasopharynx of paralytic patients. Paralysis is an uncommon happening in an otherwise mild and omnipresent disease. The person with paralysis (considered by him a complication) will not spread the disease, although his nasopharynx will.

[ED NOTE—Unfortunately one has to disagree with some of the epidemiologic facts. 1 He states that poliomyelitis is a disease of childhood. (It was, but now the age incidence is increasing.) 2 Two cases in one family are unusual. (This has not been true in our experience.) 3 Recovery leaves lifelong immunity. (This is a statement which cannot be proved.) Nevertheless, the author pens a thought-provoking essay, which must be read to be appreciated.]

Gordon³³¹ found that the serums from 3 of 37 dogs neutralized the Lansing strain of poliomyelitis virus. He found no neutralizing effect when he used the serums of 2 chickens and 6 pigeons owned by persons living in the immediate vicinity of a patient with poliomyelitis.

Perkins³³² discusses the epidemiology of poliomyelitis. It is an intelligent summarization of present day accepted principles.

[ED NOTE—I do not agree with him that the nasopharynx is the usual portal of entry and that the infection is spread by droplets. I merely state this for the record and not to dispute the author, because his is also a commonly accepted opinion. He states that insects are of little value in explaining the spread. I agree with him that water is not the way of spread and that rigid quarantine (beyond twenty-one days) closing schools and theaters is inadvisable.]

Melnick and colleagues³³³ showed that poliomyelitis developed rapidly in rhesus monkeys when human feces containing poliomyelitis virus and prepared in the ultracentrifuge were inoculated directly into the lumbar region of the spinal cord. The median incubation period in 19 monkeys so inoculated was four days. However, because of the large number of undesirable side reactions and because of the lower sensitivity of this route when compared with that of the intracerebral

330 Kendall A. I. Contagiousness of Poliomyelitis. *South M J* **38** 593-595 (Sept.) 1945

331 Gordon F. B. The Neutralization of Poliomyelitis Virus by Dog Serums. *J Infect Dis* **76** 198-202 (May-June) 1945

332 Perkins J. E. The Epidemiology of Poliomyelitis. *New York State J Med* **45** 159-168 (Jan 15) 1945

333 Melnick J. L. Horstmann D. M. and Ward R. Intraspinal Inoculation of Infective Human Stools as a Method of Producing Poliomyelitis in the Monkey. *J Infect Dis* **77** 13-24 (July-Aug) 1945

route, the intraspinal inoculation of stools is not recommended as a routine procedure

Lundbaek³³⁴ refers to Toomey's report in 1933 on involvement of the bladder and intestine, to Ehlers' reports on tachycardia in 1936 to sudden deaths from vasomotor collapse or respiratory paralysis and to the reactions obtained by him following indirect heating and postural reflexes (i.e., by changes of the heart rate to changed position). He states that it is always possible to demonstrate irregularity of autonomic regulation of heat. Normal dilation of capillaries and rise in cutaneous temperature fail to appear in the first stage of the disease with severe involvement, the normal reactions returning as the patient recovers. Examination of the postural reflex shows a rise in blood pressure on tipping the body with the head down only in patients with severe involvement.

Bodian³³⁵ found numerous multinucleated neurons in the brain, spinal cord and spinal ganglions of an adolescent rhesus monkey which had been killed during the acute state of poliomyelitis. Many anterior horn cells containing two to six nuclei showed poliomyelitic degenerative changes characteristic of those seen in ordinary neurons. A striking finding was that the nuclei in any single multinucleated cell were invariably identical or almost identical in appearance, regardless of the degree of poliomyelitic change. The interpretation of this phenomenon led to the hypothesis that the primary reaction of virus is in the cytoplasm and that nuclear degeneration in poliomyelitis, including the formation of intranuclear inclusion bodies, may reflect the general degradation of cell functions rather than direct action of the virus.

Reves³³⁶ described a hyperkeratinization of the skin in plaques, small papules or slightly verrucous elevations, with roughness and dryness of the skin and legs in 98 per cent of 84 children admitted to his hospital with poliomyelitis.

[ED NOTE—That this may be possible is admitted, but physicians with wide experience would question its occurrence. Probably the only objective cutaneous manifestation is the sense of coldness appreciated by the observer over the affected muscle, probably indicating autonomic involvement. The author suggests vitamin A because vitamin A deficiency produces changes in the myelin sheath of the nerves and further

334 Lundbaek, K. Experimental Investigation on Function of Autonomic Nervous System During Acute Phase of Poliomyelitis. *Acta med Scandinav* 114:565-583 1943.

335 Bodian, D. Poliomyelitic Changes in Multinucleated Neurons with Special Reference to the Site of Action of Virus in the Cell, *Bull Johns Hopkins Hosp* 77:49-59 (July) 1945.

336 Reves, J. G. Dermatologic Aspects of Poliomyelitis, *New York State J Med* 45:1673-1675 (Aug 1) 1945.

justifies his treatment by analogy when he states that the "virus is highly neurotropic and that it travels mainly in the nerves through the myelin sheath" This latter is news to the reviewer, who with others has long felt that the spread was along axis-cylinders and perhaps impeded by the myelin A second point might be raised To my knowledge, vitamin A has never affected the course of clinical poliomyelitis]

Turner, Young and Maxwell³³⁷ studied 303 Negro children in Baltimore for neutralizing antibodies for the Lansing strain of poliomyelitis virus Neutralizing antibodies seemed to be present in 85 per cent of the infants up to 3 months of age They disappeared rapidly and by the end of the first year of life were found in only 19 per cent, but they increased gradually, so that by the time the children were 10 to 14 years of age the blood serum-neutralizing values were found in 86 per cent of the children tested The author did tests on 34 infants repeatedly and demonstrated that there is so definite a decline that most infants give normal results by the end of six months

Kovar³³⁸ expresses the opinion that acute toxic gastrointestinal upsets are capable of producing symptoms similar to those of the pre-paralytic stage of poliomyelitis due basically to avitaminosis B and sub-clinical acute beriberi

It is suggested that all patients suffering acute simple gastrointestinal conditions encountered during epidemic periods of poliomyelitis be given large doses of vitamin B

Vitamin B is also indicated as an adjunct to treatment in all acute debilitating diseases and especially diarrheas

It is suggested that if tonsils are to be removed during the season in which poliomyelitis occurs high vitamin B intake be insured both before and after operation

In many cases the so-called abortive form of poliomyelitis may be in reality an acute gastrointestinal condition characterized by symptoms of avitaminosis B

Vitamin B plays an important part in the causation of poliomyelitis, and the nutritional aspect of poliomyelitis should be thoroughly investigated

[ED NOTE—We agree with the author that the nutritional aspects should be studied in this disease It must be remembered, however, that a connection between vitamin B has never been definitely shown and that other interpretations could be drawn from the work of Foster and co-workers (Refer to the subsequent comment) It is also strange that the therapeutic use of thiamine hydrochloride has been of little value in the hands of most workers in treating poliomyelitis]

337 Turner T B, Young L E, and Maxwell E S The Mouse-Adapted Lansing Strain of Poliomyelitis Virus *Am J Hyg* 42 119-127 (Sept.) 1945

338 Kovar W R Poliomyelitis and Acute Gastro-Intestinal Upsets *Nebraska M J* 30 394-397 (Nov.) 1945

In an editorial in *The Journal of the American Medical Association*, "Diet and Poliomyelitis,"³³⁹ it is stated that "Toomey found that vitamin D gave almost complete protection when the infective dose of poliomyelitis virus was injected directly into an exposed loop of the intestine of monkeys"³⁴⁰ It states further, "Sabin found that vitamin D did not afford protection under similar conditions and that rachitic monkeys are not more susceptible to experimental poliomyelitis than normal controls" The first part of the second quotation is in error, since to my knowledge the experiments made on the exposed loop of the intestine in rachitic and nonrachitic monkeys have never been repeated The second part of this sentence should be qualified by addition of the phrase "under the conditions of their experiments"

Sabin and associates³⁴¹ had in mind another of Toomey's experiments Flexner's MV virus strain when originally obtained by him caused the disease in monkeys when injected intrasciatically Some years later, he injected this virus intrasciatically into rachitic monkeys used as controls The rachitic animals contracted the disease, while the control monkeys did not Quadriplegia occurred in 2 control monkeys given virus intracerebrally Harrison and Woolpert,³⁴² using the same strain of virus (Flexner MV, obtained from the University of Chicago), got the same poor results by way of the sciatic nerve

Later, when Sabin's Flexner MV strain was used by Toomey, it proved to be extremely virulent, causing the disease in every animal in which injections were given intrasciatically This virus was so virulent that no comparison was possible between rachitic and nonrachitic animals when this route was used However, when in other experiments with baby rachitic monkeys the gastrointestinal tract served as the portal of entry, the rachitic animals contracted the disease while the protected ones did not

The experiments of Foster and co-workers³⁴⁴ and Rasmussen and associates³⁴³ have been repeated by Toomey and associates³⁴⁶ It is

339 Dietary Deficiencies of Poliomyelitis editorial, *J A M A* **124** 986 987 (April 1) 1944

340 Toomey J A Ingestion of Vitamins A B, C and D and Poliomyelitis *Am J Dis Child* **53** 1202-1208 (May) 1937

341 Sabin, A B, Ward R Rapoport S, and Guest G M Neuroinvasiveness of Poliomyelitis Virus in Relation to Vitamin D *Nutrition Proc Soc Exper Biol & Med* **48** 451-454 (Nov) 1941

342 Harrison, I A, and Woolpert O C Intraneural Injections of Serum as Barrier to Migration of Virus in Experimental Poliomyelitis, *J Infect Dis* **65** 214-218 (Sept-Oct.) 1939

343 Footnote deleted by the author

344 Foster, C Jones J H Henle W and Doriman F The Effect of Vitamin B₁ Deficiency and of Restricted Food Intake on the Response of Mice to the Lansing Strain of Poliomyelitis Virus *J Exper Med* **79** 221 234 (Feb) 1944

true that in more animals given a diet high in thiamine hydrochloride paralysis develops than in those deficient in this vitamin. In our experience the latter animals usually die from the dietary deficiency without showing paralysis. It, as we have found, the brains and cords of the majority of animals that die in the dietary-deficient group without paralysis contain live virus which can transmit poliomyelitis with paralysis to a second generation then one begins to wonder whether paralysis is not a sign of protection in the overt animals. The question arises: "Is paralysis the sole criterion of disease in the deficient animals?"

Pearson and Rendtorff³⁴⁷ described the results from their studies on transmission of poliomyelitis virus. Specimens of stools from almost the entire population of a village where poliomyelitis occurred in an adult were tested for virus. Virus was recovered only from the 6 year old son of the patient. Pools of specimens from 127 persons in thirty-nine families were uniformly negative for the virus. Of 30 persons associated with a patient with poliomyelitis in a small town, virus was recovered only from the stools of a 5 year old sibling and from 2 play-mates 7 and 5 years old, of another family. No virus was detected in the stools of the associates of 2 patients or from the 2 patients in a small town. Virus was not recovered from the fecal specimens of farm animals, flies and mosquitoes or the brains and intestines of rats or mice inhabiting the area where these sporadic cases occurred.

Pearson and Rendtorff³⁴⁸ studied an epidemic in a small town. After the occurrence of 2 cases of poliomyelitis, samples of stools from nearly all the children under 16 years of age were tested for the presence of virus. Members of the families of the patients also were tested. Of 282 persons in one hundred and forty-six families virus was recovered from the brother and a group of 3 cousins of 1 patient and from children of eight other families, 5 of these children were 2 years of age. From the degree of association of those found to harbor the virus it was concluded that personal association was the principal factor involved in the spread of infection within the community.

345 Rasmussen A. F. Jr. Waisman H. A. Elvehjem C. A. and Clark, P. F. Round Table and Problems in Poliomyelitis. Role of Nutrition in Response of Host to Poliomyelitis Virus Infection. (a) Influence of Thiamine and Riboflavin Deficiencies on Resistance to Theiler's Virus to Lansing Strain Poliomyelitis in Mice, *J. Bact.* **45** 85-86 (Jan.) 1943.

346 Toomey, J. A. Frohring W. O. and Takacs, W. S. Vitamin B₁ Deficient Animals and Poliomyelitis. *Yale J. Biol. & Med.* **16** 477-485 (May) 1944.

347 Pearson H. E. and Rendtorff R. C. Studies of the Distribution of Poliomyelitis Virus in the Environment of Sporadic Cases. *Am. J. Hyg.* **41** 164-178 (March) 1945.

348 Pearson H. E. and Rendtorff R. C. Studies of the Distribution of Poliomyelitis Virus in a Small Town. *Am. J. Hyg.* **41** 179-187 (March) 1945.

[ED NOTE—Unfortunately, the test animal used was the rhesus monkey, which has a good natural resistance, and virus might have been present and not transferred]

Pearson and co-workers³⁴⁹ studied the 1943 epidemic in Fort Worth, Texas. This study was an intensive one in a selected district of the city. Stools from 524 persons were tested for virus by inoculation into monkeys. Six (75 per cent) of eight households, representing twenty-seven familial contacts, gave positive results for virus, as did eighty (18 per cent) of forty-five households, containing eight nonfamilial contacts, and two (16 per cent) of one hundred and twenty-seven households, representing three hundred and seventy-four noncontacts. Virus was harbored by adults in five of the six households of familial contacts in which members harbored virus.

Virus was not recovered from specimens of water, sewage, flies, ants, cockroaches or droppings of domestic animals.

An agent that produced paralysis in mice and cotton rats was obtained from a pool of brains and intestines from 22 Norwegian rats from the city dump. No virus was recovered from several batches of mice and rats collected in various other parts of the city.

C. Kling³⁵⁰ suggests that virus may be carried in microorganisms of sewage, most likely the genus *Bodo*. Evans and colleague³⁵¹ experimented with the micro-organisms which naturally inhibit water, which were obtained from a pond, a lake and a river. They found that the organisms failed to yield significant increase in potency of several strains of poliomyelitis virus, use of six strains of *Bodo*, two of *Monas* and one each of *Pleuromonas*, *Oikomonas*, *Tetrahymena* and *Uronema* derived from sewage failed to support the growth of poliomyelitis virus to an extent that would be significant with reference to the finding of the virus in sewage.

Kabat, Wolf and Bezer³⁵² used an emulsion of rabbit brain in a mixture of saline, Aquaphor and liquid petrolatum containing dried, heated and killed tubercle bacilli in a group of 4 monkeys. Another

349 Pearson, H. E., Brown, G. C., Rendtorff, R. C., Ridenour, G. M. and Francis, F. T. Studies of the Distribution of Poliomyelitis Virus in an Urban Area During an Epidemic, *Am J Hyg* **41** 188-210 (March) 1945.

350 Kling, C., Olin, G., Fahraeus, J., and Norlin, G. Sewage as a Carrier and Disseminator of Poliomyelitis Virus. Searching for Poliomyelitis Virus in Stockholm Sewage, *Acta med Scandinav* **112** 217-249, 1942.

351 Evans, C. A., and Osterud, K. O. The Failure of Poliomyelitis Virus to Grow in Certain Protozoa of Sewage, *Science* **104** 51-53 (July 19) 1946.

352 Kabat, E. A., Wolf, A. and Bezer, A. E. Rapid Production of Acute Disseminated Encephalitis in Rhesus Monkeys by Injections of Brain Tissue with Adjuvants. *Science* **104** 362-363 (Oct 18) 1946.

group was given rabbit lung in a mixture of the same ingredients. Both emulsions contained phenol (0.25 per cent), and both were heated at 60 C for forty-five minutes to destroy autolytic enzymes. The monkeys were given three 1 cc doses intramuscularly either in the arm or in the leg at weekly intervals. A condition resembling acute disseminated encephalomyelitis with demyelination was produced rapidly after injection of the brain emulsion material only.

[ED NOTE—This use of an adjuvant in poliomyelitis was attempted by Toomey in 1934^{32,34} and later in attempts to produce a poliomyelitis serum^{3,33}]

Rivers, Sprunt and Berry^{33,4} demonstrated that repeated intramuscular injections of brain extract and brain emulsions into 8 monkeys were followed in two instances by an inflammatory reaction accompanied with demyelination in the central nervous system. The objective in these experiments was to produce acute disseminated encephalomyelitis in monkeys.

Schwentker and Rivers^{35,5} demonstrated that repeated injections of autolyzed brain material can produce paralysis in rabbits but at the time they were unable to demonstrate lesions in the nervous system to account for its occurrence.

The same authors^{35,6} attempted to determine whether injections of emulsions and extracts of rabbit brain had any observable effect on the central nervous system. Monkeys received numerous intracerebral injections, as many as eighty-five. Paralysis was produced in some animals. These workers proved that repeated injections of aqueous emulsions and alcohol ether extracts of sterile normal rabbit brains produced pathologic changes accompanied by myelin destruction.

Morgan^{35,7} used Freund's technic—adjuvants and similar means—to produce allergic encephalitis in monkeys.

Ferraro and Jervis^{35,8} injected fresh aqueous emulsion and alcohol and ether extracts of rabbit brain into monkeys, repeating the experiments of Schwentker and Rivers and co-workers and getting the same results.

353 Footnote 328 *b c and d*

354 Rivers, T. M., Sprunt, O. H., and Berry, S. Q. Observations on Attempts to Produce Acute Disseminated Encephalomyelitis in Monkeys. *J. Exper. Med.* **58** 39-53 (July) 1933.

355 Schwentker, F. F. and Rivers, T. M. Antibody Response of Rabbits to Injections of Emulsions and Extracts of Homologous Brain. *J. Exper. Med.* **60** 559-574 (Nov.) 1934.

356 Rivers, T. M., and Schwentker, F. F. Encephalomyelitis Accompanied by Myelin Destruction Experimentally Produced in Monkeys, *J. Exper. Med.* **61** 689-702 (May) 1935.

357 Morgan, I. M. Allergic Encephalomyelitis in Monkeys in Response to Injection of Normal Monkey Cord. *J. Bact.* **51** 614 (May) 1946.

358 Ferraro, A. and Jervis, G. A. Experimental Disseminated Encephalopathy in Monkeys. *Arch. Neurol. & Psychiat.* **43** 195-209 (Feb.) 1940.

Kabat, Wolf and Bezer³⁵⁹ used Aquaphor, liquid petrolatum and tubercle bacillus plus phenol to produce quickly disseminated encephalomyelitis. Three intramuscular injections were given once a week, with perhaps a second series of injections. 1 A picture resembling acute disseminated encephalomyelitis in human beings has been regularly and rapidly produced in rhesus monkeys by injection of emulsions of adult rabbit and monkey brain. 2 No lesions of the central nervous system resulted from injection of similar emulsions of fetal rabbit brain or adult rabbit lung. 3 A description of the gross and histologic changes in the central nervous system is given and compared with features of human demyelinating disease. 4 The experimental findings are in accord with the hypothesis that antibody to the injected brain emulsion reacts with the tissues of the nervous system of the animal to produce the pathologic changes.

Morgan³⁶⁰ initiated a study to enhance antibody responses to poliomyelitis virus, but sensitization to the meninges of the central nervous system overwhelmed the anticipated results.

By subcutaneous injection of central nervous tissue emulsified with adjuvants according to Freund's technique it has been possible to induce in the majority of monkeys an acute disseminated encephalomyelitis which is interpreted as an isoimmunization to tissue in the central nervous system. Positive reactions occurred only in response to tissue of the central nervous system containing white matter, i. e., cerebral white matter, spinal cord (whether normal or infected by poliomyelitis) and cortical "gray" matter (with an estimated 10 per cent contamination with white matter). No reaction occurred when peripheral nerve or kidney suspension or saline alone was injected with adjuvants. The perivascular and extravascular infiltration induced was confined to the central nervous system.

Milzer and Byrd,³⁶¹ using autolyzed brain tissue, enhanced the chances of isolating poliomyelitis virus in unknown cases.

Autolyzed brain tissue diluent shortens the incubation period and facilitates the transfer of poliomyelitis virus to CFW Swiss mice, hamsters and rhesus monkeys. The Leon monkey passage strain of poliomyelitis virus was successfully adapted to CFW Swiss mice by means of this technique.

359 Kabat, E. A., Wolf, A. and Bezer, A. The Rapid Production of Acute Disseminated Encephalitis in Rhesus Monkeys by Injection of Heterologous and Homologous Brain Tissue with Adjuvants, *J. Exper. Med.* 85: 117-130 (Jan.) 1947.

360 Morgan, I. M. Allergic Encephalomyelitis in Monkeys in Response to Injections of Normal Monkey Tissue. *J. Exper. Med.* 85: 131-140 (Jan.) 1947.

361 Milzer, A., and Byrd, C. L. Autolyzed Brain Tissue as a Means of Facilitating Transmission of Experimental Poliomyelitis. *Science* 105: 70-72 (Jan. 17) 1947.

Since this manuscript was submitted they have isolated several strains of poliomyelitis virus from infected human feces and spinal cords in CFW Swiss mice by means of this technic

Nelson³⁶² postulates unacceptable majors and minors in order to complete his syllogism, edema has not been accepted by all as a major pathologic finding, perivascular infiltration does not point to actual initial circulatory involvement per se. Perivascular infiltration may even be absent. Its presence depends on the severity and rapidity with which the disease is produced.

Some of the dictums formulated although true in themselves are irrelevant and inapplicable to the point at issue.

The writer calls attention to the fact that the left arms are more involved than the right. It seems incongruous that in one breath activity is mentioned as a possible activating intrinsic factor and just previously it is called to our attention that the less active muscles (the left arm) are actually involved three times as often as those in the right arm. It usually is the right arm that is more active. We would challenge the statement that the limitation of paralysis to the arms is a rare distribution. No one denies the occurrence of poliomyelitis in one whose arms were used as paddles but this evidence is irrelevant as is also the evidence from the next instance quoted. It is recognized by all experts of the disease that if a joint is injured the muscles about or to this joint may be involved if poliomyelitis occurs subsequently, but what does circulation in and about a joint have to do with circulation in the cord? The abstracter has given injections to thousands of persons in immunization programs and has never seen poliomyelitis develop subsequently and would want to have more evidence than that presented before believing that there is any connection.

The reference to Sister Kenny's work is inapplicable. The author frankly states that they are attempting to alter circulation of the spinal cord in animals and human beings with poliomyelitis with a view toward altering the course of the disease. Paravertebral block is one method. That this would affect muscle vascular supply is possible but the evidence the author submits for the reason for such an operation is meager. It does not follow that after such an operation the circulation of the cord is affected as is the peripheral circulation. The author is correct when he states that the results are too inadequate to warrant the conclusion that block is treatment for poliomyelitis.

Faber and Silverberg³⁶³ describe the histopathology in 8 patients with poliomyelitis who died in the San Francisco Bay district during

362 Nelson N. Spinal Cord Circulation in Poliomyelitis. *Science* **104** 49-50 (Jul. 19) 1946.

363 Faber H. K. and Silverberg R. I. A Neuropathological Study of Acute Human Poliomyelitis with Special Reference to the Initial Lesion and to the Various Potential Portals of Entry. *J. Exper. Med.* **83** 329-352 (April) 1946.

1943 and 1944 Excellent diagrams accompany this article, especially those which tend to illustrate spread from the mucosa to the central nervous system The authors attempted to trace the pathway of the virus and by pathologic and other collected evidence (clinical and other material) to point to the probable portal in each instance Doubtless in the matter of deaths reported all one could say was that these patients had the probable entry described As the authors state, in 5 cases the portals were primary bulbar and in 3 they were primary spinal in type The authors cite Hart and Bodian "that in some instances the initial entry into the central nervous system was bulbar and in some, spinal," with which conclusion the authors agree, adding that from their data the former, i e, the bulbar, appears to be the more frequent portal

[ED NOTE —We do not think that this conclusion should follow, since we do not know whether this is the portal of entry in numerous patients other than those who have died If the conclusion were qualified by the phrase "This is the portal of entry in the cases described" agreement would be obvious]

XII POLIOMYELITIS CONVALESCENT TREATMENT AND RELATED SUBJECTS

Prepared by

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The following articles concerning the treatment of patients in the convalescent phase of acute anterior poliomyelitis are divided into three groups I diagnosis and early treatment, II methods of relieving spasm, pain and contracture, and III surveys of epidemics and series of patients

I Diagnosis and Early Treatment—McIntosh and others "present the problems of treating poliomyelitis in view of present standards They point out that accuracy of diagnosis is an important factor in planning a program of treatment They recommend the adoption of controls if the sampling method of treatment is to be utilized and suggest the alternate case method Standardization of evaluation of muscles is urged in order that an objective assessment of muscular strength may be obtained early in the course of the disease, to effect such a standardization, the "zero" through "normal" terms and symbols are recommended There is a need for devising new forms for evaluation of the status of patients with after-effects of poliomyelitis, several methods are offered for consideration

364 McIntosh R, and others Evaluation of Results of Treatment in Infantile Paralysis (Committee on Standards of Scientific Advisory Committee of National Foundation for Infantile Paralysis), J A M A 128 21 22 (May 2) 1945

Toomey³⁶⁵ states that the objectives of treatment are the avoidance of deformities, maintenance of circulation and reeducation of muscles. Early and persistent physical therapy in the hands of an intelligent and well trained personnel produces better results than application of casts over a long period. Pain is of limited duration, it is best relieved with hot, moist heat. The Kenny technique is better than that of rigid immobilization, but it is not superior to other methods of early treatment, the results are not due to any particular therapy but to persistent physiotherapy."

Sweet³⁶⁶ has found in three fourths of all patients the typical prodromal signs of headache, fever, vomiting, nuchal and back rigidity and cerebrospinal fluid with leukocyte count averaging 200 to 400 cells and with increased protein content. The diagnosis may be made, however, in the presence of a normal spinal fluid. Trauma, infection, toxic sinusitis, vitamin deficiencies, meningitis, serous meningitis, meningismus and hysteria are conditions which must be ruled out. Spinal respiratory paralysis is treated in the respirator, later the patient is gradually weaned away from its use. Patients with bulbar paralysis are put into the Trendelenburg position, aspiration is done frequently, nothing is given by mouth and oxygen is used as necessary. In a series of 60 patients with bulbar and respiratory paralysis there were fifteen early and seven late deaths when these principles were followed.

Johnson³⁶⁷ expresses the opinion that all muscles should have three months of careful and painstaking protection, consisting in early splinting, passive motion when the muscle power is below 50 per cent and early reeducation of the muscles. Accurate tests of the muscle were made at three month periods in a group of cases from the 1941 epidemic in Baltimore. Johnson feels that an accurate prognosis can be made at the end of the first three months as follows: 1. Muscles which have not recovered to 30 per cent will have no return of useful power. 2. Muscles with a return to 80 per cent will have satisfactory function with no treatment except general supervision. 3. Muscles with a return between 30 per cent and 75 per cent deserve painstaking care for at least a year. No appreciable recovery continues beyond eighteen months. Regression can occur with overfatigue and too early removal of support.

365 Toomey, J. A. Present Status of Early Treatment of Poliomyelitis. *Wisconsin M. J.* **44** 780-785 (Aug.) 1945.

366 Sweet, L. K. Acute Anterior Poliomyelitis. Diagnosis, Differential Diagnosis and Treatment of Bulbar Paralysis and Respiratory Failure. *M. Ann. District of Columbia* **14** 501-504 (Nov.) 1945.

367 Johnson, R. W. Jr. Results of Modern Methods of Treatment of Poliomyelitis. *J. Bone & Joint Surg.* **27** 223-226 (April) 1945.

Wiley ³⁶⁸ presents an apparently original method of treating poliomyelitis "consisting principally of a very low calcium intake and administration of sodium acid phosphate" This treatment is based on the premise that the virus grows best in the alkaline medium of the duodenum, where calcium is released from solution Eleven patients treated with this regimen, plus hot packs and physical therapy, are reported, all patients showed an unbelievably rapid improvement Several years' trial of this procedure must be made before the end results can be evaluated

Early in the acute course of the disease the application of some form of splinting or protection, such as a brace, footboard or splint, is advocated by Heyman ³⁶⁹ A proper balance between protection and exercise should be maintained, and overstretching of weak muscles should be avoided The splint should be used to prevent stretching, contracture and fatigue until the patient has made his maximum recovery

Key ³⁷⁰ states that poliomyelitis is self limited and that if deformities are prevented the end result is determined largely by the damage done to the motor cells during the acute febrile stage Many patients recover completely without treatment, while others remain extensively paralyzed in spite of the best treatment He advocates the following treatment for the various stages (1) in the acute stage, rest and immobilization in plaster casts, which are removed once or twice each day for passive motion, (2) in the convalescent stage, reeducation of the muscles and stretching, and (3) in the chronic stage, application of braces and use of surgical treatment

Funsten ³⁷¹ analyzes the original Kenny concept and its subsequent modifications He recognizes a personality factor in the wide acceptance of Sister Kenny's methods but gives her credit for stimulating interest in the use of physical therapy He recommends use of her methods in general but abandonment of her "ritual" and urges the use of braces and surgical treatment when indicated

Schmier ³⁷² describes an apparatus which is designed to supplant the manual testing of all muscles which rate "2" (poor) or better It con-

368 Wiley, B C Preliminary Report Low Calcium Treatment of Poliomyelitis, *Ohio State M J* **41** 1103-1106 (Dec) 1945

369 Heyman, C H When Should Poliomyelitis Patient Be Splinted? *Ohio State M J* **41** 432-436 (May) 1945

370 Key, J A Indications for and Limitations of Treatment of Poliomyelitis *J Pediat.* **26** 265-272 (March) 1945

371 Funsten R V Influence of Sister Kenny Publicity on Treatment of Poliomyelitis *Virginia M Monthly* **72** 403-406 (Oct) 1945

372 Schmier A A Research Work on a More Precise Method of Determining Muscle Strength in Poliomyelitis Patients *New Muscle Tester J Prost & Joint Surg* **27** 317-326 (April) 1945

sists of a table from which triangular sections can be removed, permitting one end of the table to swivel on a ball-bearing joint. Around the edge of the table is placed a rail, to which various splints may be attached. With gravity and friction eliminated so far as possible, the force required to move a bodily segment through a given range is measured on a circular spring scale.

II *Methods of Relieving Spasm, Pain and Contracture*—Fox and Spankus³³ studied the effect of neostigmine on muscles in spasm in 24 patients with acute poliomyelitis. The degree of daily relaxation of the involved muscles was determined by measurement of increases in passive motion one hour and seven hours after administration of the drug. Results, including the total amount of relaxation, were compared from day to day. Both this group and a control group of 6 patients were treated also with hot fomentations. Neostigmine caused a partial relaxation which was neither pronounced nor constant and which was characterized by irregularity. It was concluded that the combined use of neostigmine with hot fomentations resulted in a persistent and perceptible relaxation of muscles in most of the cases of acute anterior poliomyelitis.

Brainerd³⁴ and his colleagues report observations on 100 cases of acute poliomyelitis in San Francisco in 1944 and 1945. They conclude that muscle spasm is of uniform occurrence in the early case and is of great diagnostic value. It does not appear to be due primarily to meningeal irritation; its role in the causation of muscular weakness is proved. Neostigmine relaxed spasm, at least temporarily, and the value of medication continued past the acute stage warrants further trial. The study "gave no proof or disproof that either neostigmine or Kenny packs reduce the incidence of paralysis."

Eveleth and Ryan³⁵ report their use of neostigmine in 12 cases of poliomyelitis, beginning eighteen days after the onset, in addition to the Kenny form of therapy. The results were compared with those reported by Kabat and Knapp³⁶ in 1943. There was definite relief of muscle spasm, as indicated by an increased range of passive motion one hour following the initial subcutaneous dose of neostigmine. After a four week period of neostigmine given orally three times a day, there was little further decrease of spasm. In the series of Kabat and Knapp

373 Fox, M. J. and Spankus, W. H. Value of Neostigmine in Acute Anterior Poliomyelitis. *J. A. M. A.* **128** 720-722 (July 7) 1945.

374 Brainerd, H., Katz, H. J., Rowe, A. P., Jr. and Geiger, J. C. Clinical Manifestations of Poliomyelitis. Treatment with Neostigmine and Kenny Method. *J. A. M. A.* **128** 718-719 (July 7) 1945.

375 Eveleth, M. S. and Ryan, A. J. Prostigmine in Acute Anterior Poliomyelitis. *Yale J. Biol. & Med.* **17** 351-357 (Dec.) 1944.

376 Kabat, H. and Knapp, M. E. The Use of Prostigmine in the Treatment of Poliomyelitis. *J. A. M. A.* **122** 989-995 (Aug. 7) 1943.

there was a greater decrease of spasm following the oral administration of the drug, however, in their patients this treatment was not begun until six months after the onset

Watkins and Brazier³⁷⁷ measured muscle spasm in patients with acute poliomyelitis by quantitation of the electrical discharges after five seconds of passive stretching by known weights. Twenty minute applications of hot packs, infra-red radiation and short wave produced no great change. Luminous heat and neostigmine caused a decrease in spasm of approximately 25 per cent, this was not considered sufficient to indicate a specific effect on the spasm. Irritability occurred in paralyzed muscles as well as in those without paralysis, there was no direct correlation between the degree of hyperirritability to stretching and the degree of paralysis.

Bahlke and Perkins³⁷⁸ report on the administration of gamma globulin, in maximum dosage adjusted by weight, to 56 patients with pre paralytic poliomyelitis at Elmira, N Y, in 1944. Fifty-five patients were used as a control group, and all patients received some physical therapy. All 111 patients were observed for six months after the onset. Detailed analyses of the muscles were made at two month intervals. As these analyses showed no difference in the two groups, it was concluded that the serum was ineffective.

Ransohoff³⁷⁹ gives a report of 29 patients with the disease in the acute stage treated with intocostin. Electromyographic studies on patients show that the action currents of muscles at rest can be diminished by means of administration of intocostin and intensive stretching and can be increased on effort after administration of intocostin. The dosage of intocostin was 0.9 unit per kilogram every eight hours for the first twenty-four hours, followed by 1.5 units per kilogram until muscle spasm disappeared. Intensive stretching was done three times a day, the remainder of the day was taken up with rather strenuous gymnastic exercises. Walking was instituted as early as possible. In this series, reported before any follow-up visits, there were no fixed deformities, contractures, scolioses or pelvic obliquities.

Smith,³⁸⁰ in answer to Ransohoff, urges extreme care in the use of curare in acute poliomyelitis because it is a powerful agent in causing

377 Watkins, A. L., and Brazier, M. A. B. Observations on Muscle Spasm in Poliomyelitis. Electromyographic Studies on Effect of Various Forms of Thermal Therapy and of Prostigmine, *Arch. Phys. Med.* **26**: 325-328 (June) 1945. correction *ibid.* **26**: 775 (Dec.) 1945.

378 Bahlke, A. M., and Perkins, J. E. Treatment of Preparalytic Poliomyelitis with Gamma Globulin, *J. A. M. A.* **129**: 1146-1150 (Dec. 22) 1947.

379 Ransohoff, N. S. Curare in Acute Stage of Poliomyelitis. Preliminary Report, *J. A. M. A.* **129**: 129-130 (Sept. 8) 1945.

380 Smith, S. M. Warning Concerning Promiscuous Use of Curare in Poliomyelitis, *J. A. M. A.* **129**: 707 (Nov. 3) 1945.

peripheral neuromuscular paralysis. He lists three conditions which should be fulfilled before the drug is administered: 1. The physician must have had experience with curare and be familiar with its pharmacologic action. 2. Antidotes such as neostigmine and ephedrine should be ready for immediate use. 3. Apparatus for maintaining an adequate airway, including endotracheal equipment and oxygen should be available and the physician should be skilled in their employment.

Behrend³⁸¹ discusses the use of the galvanic bath in subacute poliomyelitis. A series of 21 patients in the early convalescent stage was treated with the galvanic bath for periods of from ten to twenty minutes, three to six times a week. It was thought that spasm and pain decreased more rapidly than with other methods of treatment. The galvanic bath is an economical form of therapy, and no undesirable effects have been noted.

III *Surveys of Epidemics and Series of Patients*—Gudakunst³⁸² reviewed the statistics on poliomyelitis for 1943. During that year there was a total of 12,429 cases, constituting the largest epidemic except for those of 1916 and 1931. This outbreak was localized in the southwestern and far western parts of the United States. Some of the counties had a case rate of 300 per hundred thousand population. Some figures may be misleading, since the health departments lack uniform methods of reporting, for example, the preparalytic and abortive conditions may be recorded in various categories. In 50 per cent of the reported cases some form of crippling develops. 25 per cent of the patients will have permanent paralysis and 75 per cent will go on to complete recovery. Difficulty in diagnosis is due to vague, indefinite symptomatology, lack of specific laboratory tests and ignorance of the exact pathologic changes and of the prognosis. Communities should be organized to handle possible outbreaks. Cooperation between the public and the health agencies is needed if optimum care is to be provided.

Sherman³⁸³ reports a group of 70 cases studied during the 1943 epidemic in Chicago. The patients were given only supportive medical care during the acute stage and were discharged at the end of that time (the average stay in the hospital was 17.9 days). The patient was regarded as a functional unit, without regard to reeducation of individual muscles. Walking was encouraged as early as possible. No mention is made of resultant deformities or postural defects. At the

381 Behrend, H. J. Pain Relieving Effect of Galvanic Bath in Subacute Poliomyelitis. *Bull. Hosp. Joint Dis.* 5: 110-113 (Oct.) 1944.

382 Gudakunst, D. W. Infantile Paralysis. *Physiotherapy Rev.* 25: 71-73 (March-April) 1945.

383 Sherman, M. W. The Natural Course of Poliomyelitis. A Report on Seventy Cases. *J. A. M. A.* 125: 99-102 (May 13) 1944.

end of a six month period it was estimated that 10 per cent would require braces or surgical treatment, 72.8 per cent had slight or no weaknesses and 8.6 per cent had functionally significant weakness, the mortality rate was 8.6 per cent

Hansson and Straub³⁸⁴ made a survey of 158 patients whose onset of poliomyelitis occurred in 1944. Seventy-seven per cent were treated with hot fomentations, 12 per cent had only reeducation of the muscles and 11 per cent showed no improvement and required support, 11 per cent showed slight improvement and may require support, 19 per cent showed definite improvement and require no support, and 59 per cent returned to normal. Emphasis is placed on the need for close cooperation between all departments of a hospital, and the development of a new type of brace is urged.

Gurewitsch and Thompson³⁸⁵ report a group of 29 patients treated by the Kenny method and followed for from twelve to thirty months. At the end of this period, 12 showed poor function of one or more extremities and scoliosis was present in 7. A total of 17 patients had either poor function of one or more extremities or a significant deformity or both. Nine were dependent on braces for improved function.

384 Hansson K. G. and Straub, L. R. A Report on Poliomyelitis Cases from Hospital for Special Surgery of New York City, New York State J. Med. **46** 1009-1014 (May 1) 1946

385 Gurewitsch A. D., and Thompson, W. A. L. Poliomyelitis Treated by Kenny Method. End Result Study of Twenty-Nine Cases, Arch. Phys. Therapy **25** 726-729 (Dec.) 1944

(To Be Continued)

ARCHIVES OF SURGERY

VOLUME 54

MAY 1947

NUMBER 5

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BILATERAL LOBECTOMY FOR BILATERAL BRONCHIECTASIS

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AND

S A SWENSON Jr, M D

OMAHA

AS THE mortality of lobectomy for unilobar bronchiectasis has declined to a present level which seems almost incredibly low (less than 1 per cent in a recently reported series) the indications for the operation have been extended to include two types of cases which in the past were rejected—namely, (1) cases of minimal disease with symptoms not troublesome enough to warrant any considerable risk of operation, and (2) cases of diffuse disease, with involvement of both lungs or of both the upper and the lower lobe of one lung. This paper is not concerned with cases of the first type—those of minimal disease, suffice it to state that radical curative treatment is justified in such cases in anticipation of the inevitable progress of the disease, with increasingly distressing symptoms and with probability of considerable shortening of the life expectancy.

In cases of the second type, those of multilobar disease, there is a more urgent need of surgical intervention because in general the more widespread the disease the severer the symptoms. Patients with extensive bronchiectasis not only are invalidated early in life but suffer even more from the psychologic effect of being more or less ostracized from society, and usually they do not live beyond middle age.

The mortality of lobectomy for bilateral disease is higher than that for unilateral disease, for several reasons. One of the hazards of lobectomy is the spillage of pus and secretions into the bronchial tree during operation. This purulent sputum may drown the patient, literally, or may cause death later from pulmonary complications arising from aspiration of the material into the uninvolved lobes of the lungs. As a rule, this hazard is greater in the cases of bilateral involvement because there is a larger quantity of pus with which to cope. Furthermore in cases of unilateral involvement all disease is eradicated at the time of the original operation, but in cases of bilateral bronchiectasis a portion of the diseased and pus-containing bronchi remain to complicate convalescence. For several days coughing is painful and restricted, and drainage of the residual bronchiectasis by expectoration is not completely

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association
Memphis, Tenn. Dec 7 1946

effective. Consequently, there is a higher incidence not only of atelectasis and other pulmonary complications but of bronchopleural fistula and empyema. Finally, if the hazards are reduced merely to a basis of chance, bilateral lobectomy implies two operations and twice the risk. It is not surprising, therefore, that in 37 cases of bilateral lobectomy collected from the literature (Bradshaw and O'Neill,¹ 17 cases, Churchill,² 5 cases, Blades and Graham,³ 4 cases, Ross,⁴ 2 cases, Eloesser,⁵ 1 case, Lewis,⁶ 1 case, Edwards,⁷ 1 case, Overholt,^{7a} 1 case, Ingraham,^{7b} 1 case, and we, 4 cases, there were 5 deaths, a mortality of 13.5 per cent.

Removal of two major lobes, either total pneumonectomy or bilateral lobectomy, reduces the amount of lung tissue available for respiratory function so drastically that the cardiorespiratory capacity must be critically evaluated before each operation. It is interesting that in 3 of our 4 cases the resections did not cause reduction in vital capacity but, on the contrary, produced sizable increases. Apparently, the bronchiectatic lobes were relatively functionless. This is understandable in cases in which the diseased lobes are small, contracted, atelectatic, functionless masses. After lobectomy the residual normal lobes become emphysematous and apparently develop some increase in respiratory capacity. To realize fully the benefits of this compensatory change, three or more months should be allowed between stages of operation. Probably the principal factors responsible for increasing respiratory capacity are the elimination of infection and of coughing and their interference with respiratory efficiency. The reduction in cardiac and respiratory reserve which occurs with aging limits the use of bilateral lobectomy to children and young adults, a younger age limit than that for unilateral lobectomy.

In an article entitled "With How Little Lung Tissue Is Life Compatible" Graham⁸ reported a case in which he removed the lower and middle lobes of the right lung and the lower lobe and the lingula of the

1 Bradshaw, H. H., and O'Neill, J. F. Surgical Treatment of Bronchiectasis. *Surg. Gynec. & Obst.* **77**: 315, 1943.

2 Churchill, E. D. Resection of Lung, *Surgery* **8**: 961, 1940.

3 Blades, B., and Graham, E. A. Surgical Treatment (Lobectomy) of Bilateral Bronchiectasis, *Surg., Gynec. & Obst.* **75**: 457-464, 1942.

4 Ross, D. E. Bilateral Lobectomy (Presentation of Two Cases), *Canad. M. A. J.* **39**: 549-552, 1938.

5 Eloesser, L. Bilateral Lobectomy, *Surg., Gynec. & Obst.* **57**: 247-249, 1933.

6 Lewis, I. Bilateral Lobectomy for Bronchiectasis, *Brit. J. Surg.* **24**: 362-367, 1936.

7 Edwards, T. cited Pneumonectomy, *Foreign Letters [Paris]* *J. A. M. A.* **107**: 1650 (Nov. 14) 1936.

7a Ingraham, R. Case of Situs Inversus with Extensive Bilateral Bronchiectasis Dating from Early Childhood and with Bilateral Lobectomy. *M. Women's J.* **46**: 593-598, 1939.

7b Overholt, R. H. Bilateral Trilobectomy. Report of Successful Case. *J. A. M. A.* **109**: 127 (July 10) 1937.

upper lobe of the left lung, in two stages. Two months after the second operation the boy had a vital capacity of 1200 cc and was leading an active life without dyspnea. In 1 of our cases the middle lobe of the right lung was removed, in addition to the lower lobes of both lungs, and the patient is leading a much more active life than was possible before operation.

It is our purpose to record 4 cases of bilateral bronchiectasis cured by bilateral lobectomy. In all the lower lobes of both lungs were removed and in 1 case the middle lobe of the right lung was also excised. In all but case 2 the patients are entirely free from symptoms. In case 2 there is some residual cough and sputum because the middle lobe of the right lung and the lingula of the upper lobe of the left lung are bronchiectatic, and the disease remains because it was not recognized prior to and at operation. Eight operations and 9 lobectomies were performed in the 4 cases—all by intralobar dissection and the individual ligation technic with intratracheal cyclopropane anesthesia and frequent intratracheal aspirations. In 2 cases bronchopleural fistula with empyema developed, in each case after the first stage of operation and in both cases the fistula closed spontaneously after drainage of the empyema. There were no deaths in this small series.

In no other type of surgical case does a successful outcome depend so much on constant observation and vigilant attention to details of preoperative, operative and postoperative care. Our patients had the constant attention of special nurses trained to encourage coughing and alert to any interference with a free airway. A resident surgeon skilled in tracheobronchial aspiration was always immediately available. The hemoglobin and the red cells were maintained at normal levels by the liberal use of blood transfusions before, during and after operation. The tracheobronchial tree was kept free of sputum as completely as possible by postural drainage before operation and by frequent tracheobronchial aspirations during and after operation. Chemotherapy was utilized prior to and after operation, first, with the sulfonamide drugs and, later, with penicillin, when it became available. Oxygen was administered in a tent as long as the patient felt that it was beneficial.

Of inestimable importance is the fact that all the patients are enjoying not only good health but normal lives, which the cough previously denied them. The 2 boys have resumed schooling which they had been compelled to give up, and the maiden has married.

REPORT OF CASES

CASE 1—R. H., a youth aged 19, had pneumonia at the age of 3 and since then had had a chronic cough productive of as much as 10 ounces (300 cc.) of sputum daily. At times the sputum had an odor but had never contained blood. He had had

8 Graham, E. A. With How Little Lung Tissue Is Life Compatible. Report of Patient from Whom All Pulmonary Tissue Except Two Upper Lobes Was Successfully Removed. Surg. 8:239-246, 1940.

pneumonia twice, the last time after tonsillectomy. For several years he had been chronically fatigued and abnormally dyspneic on exertion, and he was depressed because his cough made it impossible to continue in school and caused "people to look at [him] as though [he] had T. B." He stated that life was not worth while unless he could be rid of the cough and that he was willing to accept a considerable risk in prospect of a cure.

The abnormal physical findings were underdevelopment, clubbing of the fingers and toes, a moist cough and coarse rales at the base of both lungs. The laboratory findings were normal except for leukocytosis, with a count of 12,400, and the roentgenographic evidence of bronchiectasis of the lower lobes of both lungs and the middle lobe of the right lung. In the standard anteroposterior roentgenogram there were triangular areas of increased density at both bases medially, and in the bronchograms there was saccular dilatation of the bronchi of the lower lobes of both lungs and the middle lobe of the right lung. The vital capacity was 2,700 cc.

On Aug. 21, 1942, after four days of postural drainage every three hours, forced feeding and administration of sulfadiazine, 4 Gm. daily, the lower lobe of the left lung was removed by the individual ligation technique through a posterior lateral incision carried through the bed of the seventh rib. The bronchial stump was closed with a central ligature, two mattress sutures and a row of interrupted sutures turning the cut edges. The stump and the pleural cavity were dusted with 5 Gm. of sulfanilamide crystals. Expansion of the upper lobe to fill the chest cavity was immediately obtained and maintained by means of constant suction applied through two air-tight catheters left in the pleural cavity.

A transfusion of 500 cc. of blood and 500 cc. of dextrose in saline solution was given during operation and 1,000 cc. of 10 per cent dextrose in distilled water a few hours after operation. Subsequently, water balance was maintained by oral administration. Five hundred cubic centimeters of blood was given on the day following operation. The patient was in an oxygen tent for two days, and tracheobronchial aspirations were done two to five times daily for four days. A daily dose of 3 to 5 Gm. of sulfadiazine was given for five days after operation. The catheters in the pleural cavity were removed on the sixth day, and convalescence was uneventful until the tenth day, when there developed evidence of increasing fluid in the left side of the chest and expectoration of large quantities of thick yellow sputum. On the thirteenth day the wound bulged in its lower portion when it was opened a large quantity of pus escaped. Since drainage was not dependent a segment of the eighth rib was resected for open drainage two days later. Constant suction was applied and in five days the bronchial fistula had closed and seven days later the thoracotomy wound was healed and the patient discharged from the hospital.

On Jan. 15, 1943 the patient returned for the second operation. There had been notable reduction in the quantity of cough and sputum. The vital capacity was 2,250 cc. On January 18 the lower and middle lobes of the right lung were removed by intralobar dissection and the individual ligation technique as in the previous operation. Tracheobronchial aspiration was done only once on the evening of operation. Convalescence was uneventful, and the patient was discharged from the hospital twelve days after operation. The care was essentially the same as that given at the first stage.

When last examined eighteen months after the second operation the patient had no cough, felt that he had normal good health and had gained 20 pounds (9.1 kg.) in weight. He was normally active without dyspnea and fatigue and had gained weight from high school. His vital capacity was 2,500 cc.

CASE 2—A. S., a girl aged 19, complained of a chronic cough for a period of 4 to 8 ounces (125 to 250 cc.) of thick yellow sputum daily for a period of

years, following pneumonia. At no time had the sputum contained blood or had an odor. She had lost weight and strength and had been compelled to drop out of high school. A year previously radical operations had been performed on both maxillary sinuses.

Physical examination revealed no abnormality except for slight clubbing of the fingers and coarse rales over the bases of both lungs posteriorly. Laboratory findings were normal, and the vital capacity was 1,650 cc.

Bronchograms revealed cylindric bronchiectasis of the lower lobe of the left lung and saccular bronchiectasis of the lower lobe of the right lung. The bronchi of the other lobes were filled and were normal.

On Jan. 9, 1943 the lower lobe of the right lung was removed, and on June 6 the lower lobe of the left lung was resected. Both operations were performed through the beds of the resected seventh ribs and both by intralobar dissection and the individual ligation technic. In both instances convalescence was uneventful but was more trying and prolonged after the first operation on account of the cough. The general plan of care was the same as that in case 1.

Because the patient was not entirely relieved of cough and sputum bronchograms were made six months after the last operation. These studies showed residual saccular bronchiectasis in the middle lobe of the right lung and in the lingua of the upper lobe of the left lung. The disease in these lobes had been overlooked in the original bronchograms owing probably to the distortion resulting from the complete atelectasis of both lower lobes.

The patient has refused to have another operation for removal of this residual disease because she feels quite well and the cough and sputum have been reduced to an amount which she considers inconsequential. She married two years after her operation. The vital capacity at the time of the last examination was 2,000 cc.

CASE 3.—L. J., a youth aged 15 entered the University Hospital immediately after a gross hemoptysis. He gave a history of chronic productive cough following pertussis at the age of 1 year. The sputum at times had been foul but there had been no previous episodes of hemorrhage. At 8, and again at 10 years of age he had had pneumonia. Because exertion excited paroxysms of coughing he never had been able to participate in athletics.

Examination revealed a thin but well developed lad with much clubbing and slight cyanosis of the fingers and toes. There were diminished excursion of the left hemithorax and dullness, rales and diminished breath sounds throughout that side. At the base of the right lung were coarse rales.

Laboratory studies showed nothing abnormal except for anemia (hemoglobin 9.5 Gm. per hundred cubic centimeters and red blood cells 3,260,000).

A standard roentgenogram of the chest showed patchy areas of increased density throughout the left lung, elevation of the left side of the diaphragm, narrowing of the intercostal spaces on the same side and some displacement of the trachea to the left interpreted as patchy atelectasis from recent hemorrhage. In the right cardiophrenic angle was a triangular area of increased density.

Bronchograms made eight days after admission revealed pronounced saccular bronchiectasis of the lower lobes of both lungs. The bronchi of the remaining lobes appeared normal. At this time the vital capacity was 2,400 cc.

Normal values for hemoglobin and the red blood cells were established with transfusion of 700 cc. of blood and on Aug. 3, 1944 the lower lobe of the left lung was removed by the technic previously described. Penicillin 150,000 units daily was administered intramuscularly four days prior to and seven days after operation. A bronchopleural fistula with empyema developed on the tenth day and drainage

was established two days later. Closure of the fistula and empyema cavity was accomplished in eighteen days.

On Feb 10, 1945 the lower lobe of the right lung was removed by the technic previously described, and convalescence was uneventful.

A year later the patient was well, entirely free of cough and leading a normal life as a high school student. He had gained 28 pounds (12.7 Kg) and his vital capacity was 2,800 cc.

CASE 4—D W, a housewife aged 23, had a chronic productive cough which followed whooping cough in infancy. At times she had raised as much as 12 ounces (360 cc.) of sputum daily, and frequently it had an offensive odor. On six occasions during the past two years she had coughed up from 4 to 8 ounces (125 to 250 cc.) of blood in the course of a few minutes, and often the sputum had been blood streaked. During this period she had lost 20 pounds (9.1 Kg) in weight and had been unable to work. One year prior to consultation she was hospitalized for four months in a tuberculosis sanatorium. On two occasions, nine and six years prior to examination, she had had pneumonia.

Examination revealed a pale poorly nourished and underdeveloped woman appearing much older than her years. There were moderate clubbing of fingers and toes and coarse rales at the base of both lungs. Both lobes of the thyroid gland contained small adenomas.

Laboratory studies gave normal results. The vital capacity was 2,100 cc.

The lower lobe of the left lung was removed March 11, 1946, and the lower lobe of the right lung on May 23, 1946. Both operations were performed through an intercostal incision without resection of ribs and by intralobar dissection and the individual ligation technic. Penicillin was administered before and after operation, as in case 3.

Convalescence after each operation was uneventful, and the patient has reported that she feels well and has been free of cough since the last operation.

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DISCUSSION

DR. JOSEPH W. GALE, Madison, Wis. Dr. Bisgard and Dr. Swenson are to be congratulated on their excellent results with bilateral lobectomy. Patients such as those reported on, with diffuse bilateral bronchiectasis, present not only the greatest dangers, but the greatest difficulties, in salvage. They have suffered from a long-standing chronic infection and all have some degree of amyloidosis. The entire bronchial tree is constantly bathed with a copious putrid purulent exudate, which is capable of inciting acute exacerbations in the form of pneumonitis, pulmonary abscess and atelectasis.

The authors have given several reasons for the high operative mortality and have enumerated some of the methods employed to combat it. Since the problem of pulmonary resection unilateral or bilateral is gaining increasing attention I feel justified in making a few additional suggestions which my associates and I have found of great value in our handling of patients undergoing this operation. The authors have mentioned the importance of preoperative and postoperative care and we are in entire agreement with their conclusions. When we approach these cases we determine the susceptibility of the organisms to the sulfonamide drugs and to penicillin. Before operation we frequently place our patients under treatment with both drugs. We usually employ sulfadiazine four to seven days prior to operation. A dose of 4 Gm is given daily, care being taken to give

fluids and to watch the urine. Before operation penicillin in the form of a spray is given by inhalation every two hours the patient receiving 200 000 units daily. Only penicillin in crystalline form dissolved in distilled water is used. It is most important that only an atomizer providing a very fine spray be employed. All preparations of penicillin other than the crystalline form have proved undesirable, chiefly because of the pungent urinous odor which they impart to the air of the ward and to the patient. Most patients refuse to use them. Postural drainage is probably the most important preoperative measure and must be employed frequently and effectively for several days prior to operation and continued until the amount of sputum is reduced to a minimum as judged by a low level of expectoration for several days. The patient should be given postural drainage just before coming to the operating room, and great care must be taken during the operation to prevent spillage into the opposite lung. If the patient is operated on while lying on his side, a Trendelenburg position should be assumed and an open airway maintained throughout the procedure accompanied with aspiration of the trachea by catheter. If the patient is placed in the prone position the same technic should be employed. Immediately after operation bronchoscopic examination and careful aspiration under direct visualization should be performed on all patients. It is surprising how much secretion can be removed by this method, even though apparently effective aspiration was carried out throughout the operation. Our patients are all given oxygen by intranasal inhalation after operation and may be permitted to sit in a chair while still receiving this therapy. We feel that it is more adaptable to free movement than is the oxygen tent. In our last series of 51 lobectomies for bronchiectasis we have had 2 deaths, 1 directly attributable to spillage of pus into the opposite lung. This occurred in spite of all precautions enumerated. The other patient died after a reaction to transfusion. In this series of patients we encountered only 2 who needed bilateral lobectomy. It has been our experience that many patients will show such great improvement in the opposite lung after operation that they will not permit further surgical treatment. There are a few, however, who will require the bilateral operation. It has been our practice to attack the side of the greatest involvement in the first procedure.

Such operations as have been described by the authors would have been ill advised, and next to impossible, less than a decade ago. The intralobar individual ligation of the vessels accompanied with efficient closure of the bronchus and reinforced by careful preoperative and postoperative medication and care has rendered this operation safe.

DISCUSSION

DR THOMAS J. KINSELLA, Minneapolis: I congratulate Dr. Bisgard and Dr. Swanson on their excellent work. It takes a great deal of courage and skill and a well coordinated team to handle this type of work successfully. Bilateral bronchiectasis by and large is not suitable for surgical treatment. Many patients have too extensive involvement to permit successful resection with recovery.

The patient must be studied carefully and adequate bronchograms made so that the surgeon may know what he is dealing with before he operates. Inadequate bronchograms will often deceive the surgeon. He will find after the operation that he has overlooked involvement of the upper lobe and that the patient still has symptoms.

I agree with Dr. Gale that many of the patients who have bilateral bronchiectasis are willing and happy to go along without their second operation. Resection of the most diseased lung may be followed by sufficient improvement to satisfy both patient and physician. There should be a considerable interval between the

attack on the first side and that on the other. It may take the patient several weeks or months to regain his breathing capacity on the side of operation. If the operations are done too close together, the patient is subjected to too great a strain on his cardiovascular system.

One must be careful about performing bilateral resections on older persons. This work should be limited to children and young adults who have more or less elastic lungs, but even they should not be left with such a reduced vital capacity that they become respiratory cripples.

One must realize that the Trendelenburg position alone does not protect the patient against aspiration of sputum into the opposite lung. With the patient in the Trendelenburg position particularly in the lateral decubitus position secretions may easily run from the lower lobe on the side of operation to the upper lobe of the opposite lung and cause considerable trouble. That is particularly true during mobilization of the lower lobe.

Adequate preoperative preparation and postoperative care are essential in the field. The patients are a hazardous group to tackle, and the authors are to be congratulated on their excellent results.

DR CLIFFORD C NESSELRODE, Kansas City, Kan. May I ask Dr. Bigard that, in opening the final discussion, he give us an estimate as to the time elapsing between the two operations? He inferred that the patient went home for two or three months. In other words, he made no mention of the time that elapsed between the two operations.

DR J. DEWEY BIGARD, Omaha. I thank the discussants for their contribution. With regard to Dr. Gale's comment on the position of the patient on the table, I operate with the patient sitting up. I feel that, since the disease is confined to the lower lobes, the bronchial secretions are less likely to get into the upper lobes with the patient in this position. Graham pointed this out.

I have 3 patients with bilateral disease on whom I have operated with the intention of doing a bilateral lobectomy, and I have removed as I always attempt to do, the most diseased lobe first. These patients are happy with the result obtained from the removal of one lobe and do not wish to have the second operation. I think that is not an uncommon experience.

About three months is the least time that has elapsed between the two operations—from three to six months—and I agree with Dr. Kinsella that it is well to allow this time for the remaining lung to become emphysematous and adjusted to the expansion necessary to fill the chest. I am sure that emphysematous lungs gain respiratory capacity in time. I think that also answers Dr. Nesselrode's question.

SEAMLESS PROSTHETIC HANDS A TECHNIC OF FABRICATION

CARL D CLARKE, Ph D

FELIX B WEINBERG

AND

GEORGE C BLEVINS, DDS

BALTIMORE

I THE MAKING OF THE MOLD

THE MAKING of naturalistic, seamless, prosthetic hands of plastic materials such as rubber latex and Plastisol has presented numerous difficulties. We have not been able to find any evidence of plastic materials such as gelatin being employed for prosthetic hand making. When it became common practice to compound rubber latex in this country, one of us (C D C) experimented with this material for making prosthetic hands and facial features. Molds of plaster, agar, rubber, metal and wax were used. The agar mold first seemed to be the most logical, because by the use of this material a comparatively seamless cast could be produced. However, the mere fact that a new agar mold, or negative, had to be made for each positive, or cast, caused this material eventually to be discarded. Early experiments about eighteen years prior to the writing of this paper with gypsum cements and low fusing metals produced good molds for prosthetic hand casts, but invariably the molds had to be made as two or more pieces. The resulting casts would be detached with unsightly seam lines where the pieces of the mold joined. Nevertheless, more than one cast could be obtained from a single mold. To get away from these seam lines, the wax positives were made from seamless agar molds, which in turn were heavily electroplated with metal to form metal molds. From these, seamless rubber prostheses were produced. At this early date the plasticized or resilient resins had not been discovered. Nevertheless, the necessity of making an agar mold, then a wax positive, then a metal mold and finally the rubber cast created too many steps in the development. The final result invariably suffered from the multiplicity of processes. To eliminate this difficulty metal molds were electroplated directly onto hands from fresh cadavers. The hand was then

From the Plastic Artificial Eye and Restorations Research Laboratory, Veterans Administration University of Maryland School of Medicine and College of Physicians and Surgeons

removed from the resulting mold by maceration. At that time, before social security, cadavers were comparatively easy to obtain. This method was eventually discarded in spite of the fact that it gave good one piece molds. When it was learned how to build up coagulum deposits of rubber on agar molds, just prior to the past war, the use of one piece agar molds for making seamless rubber hands was revived. At that time the major portions of the book "Facial and Body Prosthesis" were written to fulfil a contract with the publisher. As a result of shortages, this book did not leave the presses until the last year of the war.

In the last few years further experiments with one piece rubber and metal molds have been carried out, the results of which are now being reported.

SHRINKAGE OF RUBBER

Before the discovery of the resilient resins, rubber was the best material for use in the making of naturalistic prosthetic appliances. In the case of hands being made in nonabsorptive molds, such as those of agar and metal, rubber presented a decided difficulty. Its extreme shrinkage on forming in such molds was a definite disadvantage. The resulting seamless hand of an adult, though perfect in details, would appear to be that of a child. Experiments were therefore begun to find ways of enlarging these hands. At first the vulcanized latex hands were swelled in benzene and then remolded in plaster for succeeding rubber casts. It was then found that by soaking the hands in a solution of liquid petrolatum and oil-free naphtha they could be enlarged and fixed at practically any desired size without an appreciable loss of strength or detail. The final size of the hand was determined by the amount of liquid petrolatum in the oil-free naphtha. About 20 per cent was generally sufficient. The hands were simply soaked in this mixture until they reached huge but naturalistic proportions. They were then carefully removed and dried on clean blotting paper. The oil-free naphtha volatilized, leaving the nonvolatile oil infused into the cast. Experiments were also run on castor oil as an enlarging agent because this oil has little or no deleterious effect on rubber. It has also been found that by soaking the rubber cast, fresh from the mold, coagulated and wet, in the naphtha mixture there is far less tendency for the unfilled rubber cast to turn dark. This has always been a difficulty to overcome with rubber prostheses.

THE RESILIENT RESINS

With the discovery of the resilient resins, it was found that the materials resisted the darkening effect of sunlight more readily than rubber. Rubber mixtures in which the filler content is kept low enough to produce the same translucency will invariably darken on exposure

exposure to sunlight. Furthermore, the shrinkage of the resilient resins was negligible, even when cast in nonabsorptive molds. However, the first resilient resins to appear on the market were extremely weak in comparison to rubber and furthermore, they were more difficult to use. For this reason we continued to experiment with both materials to arrive at definite conclusions about each. At the present one material is fully as important as the other. Rubber serves best for making molds of hands while the new improved and stronger resilient resins serve better for the actual prosthetic hand. However, the problems of compounding the materials and the mechanics of making molds and casts with these new materials have been many. It is surprising to find that even today most prosthetists employ piece molds, which result in casts with seam lines around each finger and up the sides of the wrist.

THE MAKING OF THE SEAMLESS MOLD

As a result of the average prosthetic hand being worn over a mechanical device and the fact that the wrist is kept under a coat or dress sleeve, the hand is seldom made to extend more than 5 or 6 inches (12 or 15 cm) above the joint of the wrist and hand. However, this does not mean that the entire arm cannot be cast. Indeed, by the method to be described, we have cast entire arms as seamless prostheses. Such prostheses are desired by women for evening wear when the arm or most of it is exposed. Where the stump of the natural arm is between the shoulder and elbow the prosthesis can be made to fit at this juncture. Join lines can be hidden beneath broad bracelets. In this way, low-cut evening gowns exposing the shoulders may be worn.

Before one attempts to make the mold, the hand and wrist are shaved to about 1 inch (2.5 cm) above the point where the prosthesis is to begin. Care should be taken that the skin is not cut, because every defect will be reproduced in the mold—even old scars and the fingerprint pattern. Furthermore, if a cut bleeds during the molding process, a considerably larger area of the detail will be lost.

A suitable glass or enamelware receptacle of sufficient depth to take the hand and wrist is secured. This must have a neck whose diameter will allow easy passage of the hand with extended fingers. Should the fingers be allowed to come together during succeeding dippings, the rubber surfaces will probably stick. Of course, this may be prevented by giving the hand a coating of talc after each drying and between each dipping. However, this is not necessary, and nothing must be done to cause one coat of rubber to separate from a succeeding coat. If the mold is not properly made, this may happen during the curing of the cast. The receptacle is filled with vulcanized latex. This can be pure Vultex.¹

alone, such as H222, or it can be filled up to 20 per cent by volume with such fillers as cork dust, diatomaceous earth, wood flour or Vultex filler H222 part B. We prefer to use the Vultex filler, because it contains a sufficient amount of zinc oxide to thicken the latex, giving heavier coats. However, the latex mix must not contain more than 20 per cent filler.



Fig 1—A the subject's old type prosthetic right hand covered with a glass and his normal left hand. B a comparison of the patient's right hand with that of the donor. C the donor's hand is shaved of hair in preparation for making the mold. D the hand is then dipped into the latex mixture.

Otherwise, the resulting mold will become stiff and more difficult to remove from the final prosthetic hand.

The bubbles that collect on the surface of the latex mix should be allowed to disappear or be expelled with the flame from a Bunsen burner. These air bubbles gather in the liquid during mixing or pouring.

the hand is dipped into the mixture while the bubbles are on the surface they are sure to collect on the hand and may destroy some of the final details of the mold. However, if they are broken by air blown on the dipped hand, the second dipping will fill the uncovered areas left by the broken bubbles.

The hand is dipped for the first time. No previous preparation of the skin other than shaving is necessary as the finished rubber mold separates readily from the hand on drying. The fingers must be held well apart to prevent sticking. Furthermore they should be relaxed but comparatively straight. One would reason that the fingers should assume a bent position, as when they lie at rest. This is a fallacy, because once they are made as positives in the plastic rubber, vinyl chloride or other resilient resins they may be bent into any desired position. If the mold is made over bent fingers, the deep depressions and folds of the skin are recorded both in the negative and in the positive and are not lost even when the fingers of the positive are straightened. However these bends or folds will appear in the bent prostheses if the fingers are molded straight.

After each dipping the hands are allowed to drain back into the receptacle until only a slow drip is apparent. The hands are then removed and held over a heating device such as a gas flame or an electric heater to aid in drying. Care must be taken not to get the mold warm enough to burn the donor.

Twisting of the wrist or movement of the fingers should be kept at a minimum as the latex dries. Otherwise, a spiral distortion may appear at the wrist. If the latex forms drops or thin areas in spite of shaking, these can be painted over with a brush. In fact, a brush dipped in latex can be used to advantage to extend the mold up the arm should the dipping receptacle not be deep enough. The hand may be held above the head or in any desired position so long as it is not twisted or bent at the wrist.

If molds are to be made in quantity production, it is a good practice to have a drying cabinet constructed with openings at the top into which the donor may insert his hand. It generally takes from six to eight dippings to make a mold of sufficient thickness to be used. If the mold is too thin, it will be drawn out of shape by the weight of the material used in the positive on drying or curing. If it is too thick, it is difficult to remove the positive from the negative. The average time consumed in making a good one piece rubber mold of a hand is from two to four hours. However, there are methods by which this time factor can be greatly reduced.

When the third coat has dried, the edges of rubber where the mold joins the skin of the arm are loosened and rolled down for about $\frac{1}{2}$ inch (1.27 cm) until they form a circular cuff. The dried rubber will stick together during this rolling process to form the cuff.

At this point it is also advisable to attach the grommets or rings for suspending the mold during the pouring, drying and curing of the positive. These can be held with a pair of forceps or hemostats dipped

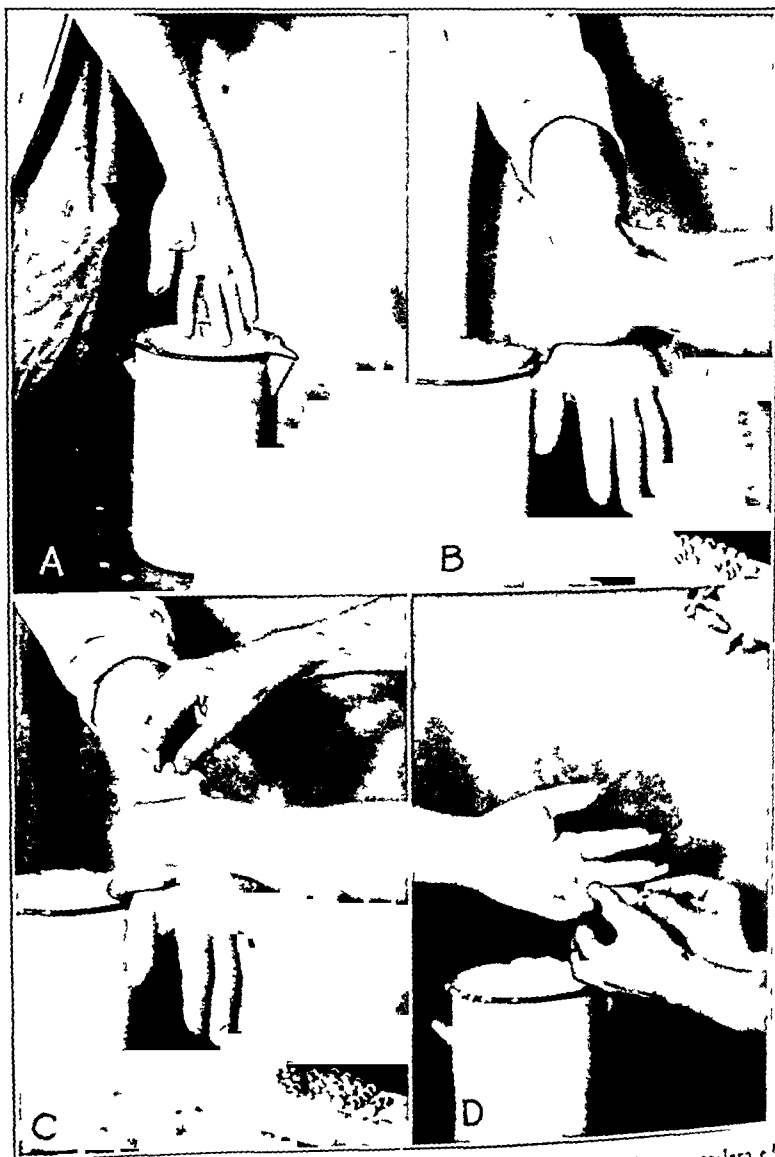


Fig 2—A, after each dipping the hand is allowed to dry. This is accelerated over an open flame gas burner or electric heater. B to create the cuff the edge of the mold is rolled down about three times. This is done after the third or fourth dipping. C, the hanging rings are dipped in latex and applied to the rolled cuff. D a hanging ring can be put on the end of each finger. However one or two on the middle fingers are sufficient.

individually into the latex mix and then placed on their edge on a block of plaster of paris to dry. After a few minutes, they will have dried with a facet at their base. This facet is dipped in latex and held in place at each finger tip and on the rolled cuff of the rubber mold. They stick immediately. In a few minutes, the dipping can be continued to build up the desired thickness to the mold. The subsequent dippings will cover the attached rings and further incorporate them within the body of the mold.

When the last dipping is thoroughly dry, the mold should be dusted with talc to keep it from sticking together on the removal of the hand. The mold is then grasped by the ringlike cuff and pulled away from the donor's hand, which separates without difficulty. However, should any attempt be made to remove the mold before it is thoroughly dry, it will either tear or be stretched out of true proportion. It is best to allow the mold to dry further for a few hours at room temperature or a few minutes in an oven at 90 C to be sure of complete drying. Before it is used for the positive, the mold should be turned inside out and thoroughly washed with warm soapy water, after which it is ready to use, for a rubber or resilient resin cast.

CARE AND TREATMENT OF MOLDS

The rubber mold when not in use should always be hung by one of the rings at the wrist end. Cup hooks serve admirably for this purpose. Molds should never be laid or stacked away, as this causes them to lose their shape.

The making of the positive rubber and resilient resin casts will be discussed in the following sections.

II PROSTHETIC RUBBER HANDS

As mentioned at the end of the previous section, when the rubber mold is removed from the donor and the rubber is thoroughly dry, it is washed inside and out with soap and water and then allowed to dry again. In making rubber casts in rubber molds, one is faced with two major problems. The first is that of separating the cast from the mold. Rubber casts can be separated from rubber molds without difficulty if the proper separating medium is used. In preparation of the mold for rubber casting, the separating medium is applied first and allowed to dry. Then the coagulating agent is put on and also allowed to dry before the rubber latex is poured into the mold. The second problem is to build up a uniform thickness of rubber against the mold which is nonabsorptive. Generally this deposit is about $\frac{1}{8}$ inch (0.32 cm) in thickness. It is achieved by application of a thin layer of a coagulating agent to the mold. If the mold were of porous, dry, gypsum cement, such a deposit could be built up by absorption of water into the mold from the rubber. Since

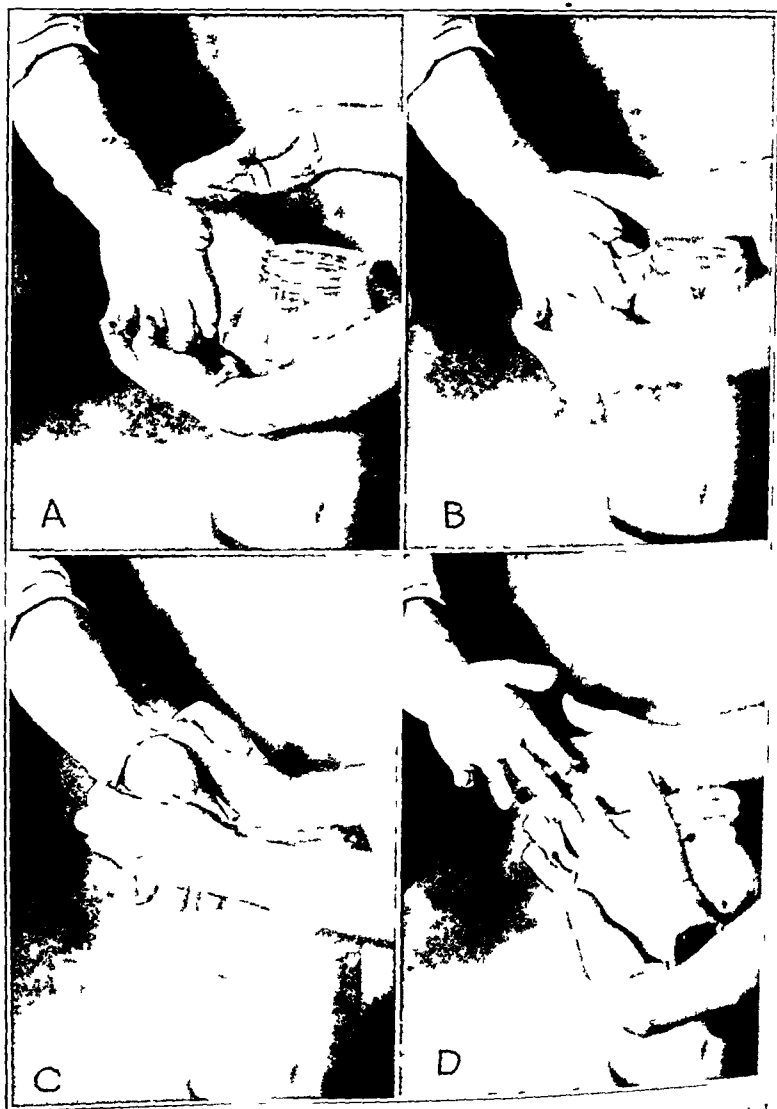


Fig 3—4, after the last dipping the outer surface of the mold is treated with talc to prevent sticking of the surfaces on removal. B the mold is removed after talcing. C the mold is stripped from the patient. D the mold is stripped inside out in the stripping process.

there is no such absorption into a rubber mold the coagulating agent is necessary

SEPARATING MEDIUMS

Shellac or lacquer serve well for a separating medium. However, both must be diluted considerably with their proper solvents before use. Furthermore, the solvents must be chosen which will have no ill effect on the rubber mold. We prefer to use white shellac, because it is less



Fig 4—A the dried rubber mold is treated with a clear thin shellac separating medium. B it is then hung in the oven upside down to dry. C after drying it is treated with a coagulating agent. This is allowed to dry thoroughly in the oven before the latex is poured. D the mold is placed on a heavy wire hanger and held above the hot water. As the latex is poured the mold is allowed to sink into the water. In some cases it is preferable to strain the latex as it enters the mold.

expensive than lacquer. Also the solvent for shellac is alcohol, which is less offensive in odor than acetone, amyl acetate and other organic solvents for lacquer.

If dry shellac is used, it must be cut with twenty times its volume of alcohol. A small amount of sodium borate should be added to the mixture to hasten the dissolving of the dry shellac into the alcohol, a process which might otherwise take days.

It is more convenient to purchase the white shellac as a 4 or 6 pound (1.8 or 2.7 Kg.) cut of liquid shellac. Then the volume is doubled or tripled by simply adding more alcohol. A jar of this mixture is allowed to stand until an opaque, light sediment sinks to the bottom. The clear, transparent liquid that rises to the top is carefully poured or siphoned off. This is the mixture most suitable as a separating medium. It is simply poured from a big-mouthed jar into the mold. The mold is then inverted, and the excess shellac is poured back into the bottle. The mold is then hung by the rings on the fingers to drain back into the big mouth bottle. Drying can be materially hastened by placing the mold in an oven at about 90 C. If a coating of shellac has any tendency to crack, a small quantity of castor oil should be added to the liquid. However, if too much castor oil is used, the dried coat becomes sticky and is unsuitable. It may be removed with alcohol.

COAGULATING AGENTS

There are many coagulating agents for rubber. Where a thick deposit is necessary, it is advisable to use a concentrated latex. The thickness of the deposit is dependent on a number of factors, some of which can be controlled at the compounding stage. If unvulcanized latex is used the simple addition of the vulcanizing ingredients increases the viscosity of the latex. The addition of 2 or 3 per cent of zinc oxide in particular has been found to have an appreciable thickening effect on latex. If more than 5 per cent is added, a complete coagulation of the entire mixture may result. Some soluble metallic salts, such as calcium sulfate in small quantities (0.3 per cent of the dry rubber content), cause a slight thickening and render the latex sensitive to local heating. By this addition or pretreating of the latex mix, a firm, thick coagulum may be built up when the mixture comes in contact with hot surfaces. Salts of magnesium and zinc also serve for this purpose.

Other coagulants commonly employed are acetic acid, formic acid, calcium chloride, acetate, nitrate or formate, zinc chloride and ammonium acetate in water. Acetone or alcohol solutions are also used, depending on the molding material and the conditions under which it is desired to effect a coagulation. Methyl alcohol has been of value because of its readily wetting properties. Two or more coagulants have been used together, as, for example, calcium chloride (2.5 per cent) in equal parts of methyl alcohol and water. In fact, we have found calcium chloride and acetic acid among the best coagulants for prosthetic work, according to the problems to be solved. The coagulating agent may be pre-

or sprayed on the surface of a mold, or it may be poured into a closed mold and drained out. It may or may not be dried on the form. A coagulant should be chosen and applied in such a manner that the rubber

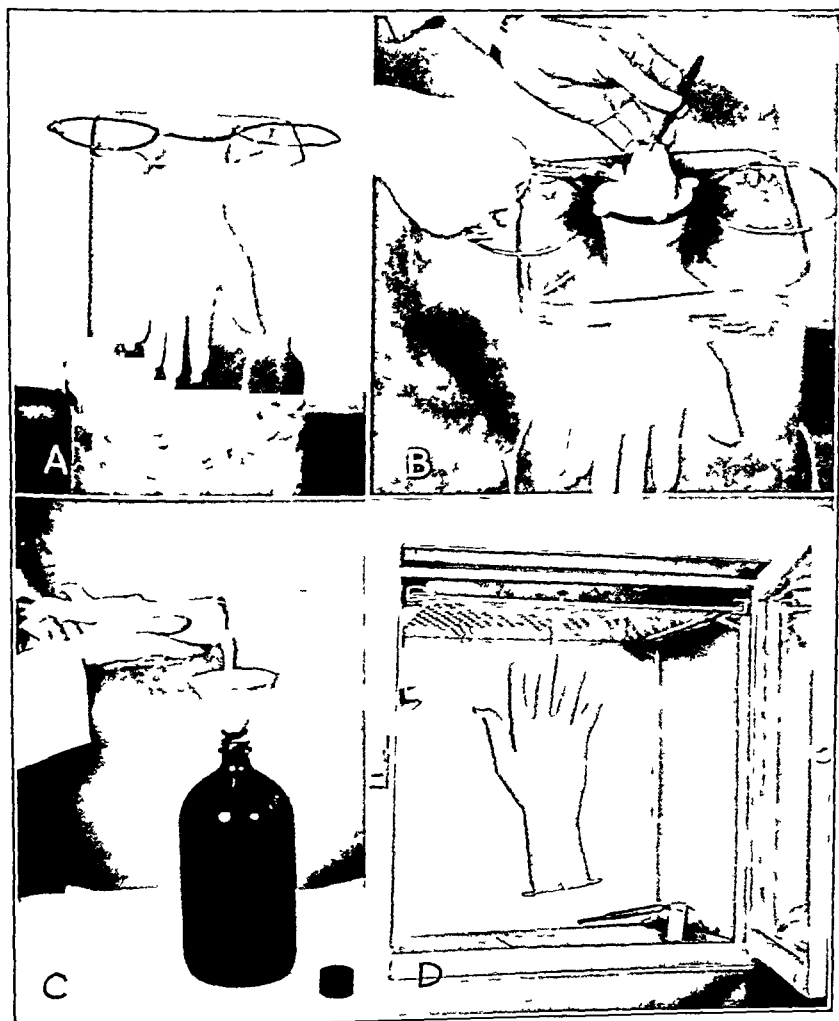


Fig 5—*A*, the mold is allowed to remain in the hot water until a coagulum of sufficient thickness is deposited on the surfaces of the mold. *B*, a coagulum deposit also builds up over the entrance to the mold. This is cut away with sharp scissors and removed. *C*, the excess latex is then poured back into the original container. *D*, the hand is then placed in the oven at about 90 C for an hour or more for drying and curing. It dries better if it is hung from the wrist end after complete drainage has taken place and the drying has begun.

will be coagulated immediately, so that there will be little tendency for the latex to flow or cause sags." Sags may be the result of two thin coagulated surfaces of latex between which is a deposit of uncoagulated

latex. In other words, they may be produced by coagulation of one layer over another in the same mold, a practice which is not always recommended. It is always best to try to build up a deposit of sufficient thickness in one pouring. After the deposit is made, it must be dried. In the case of prosthetic rubber hands, a melted microcrystalline wax may be poured into the hollow hand before it is removed from the mold, to prevent shrinkage of the rubber and to make the hand of practical use. In such a case an unvulcanized latex formula may be used because the hot wax will vulcanize the thin deposit of rubber. However if the hand is to be enlarged by swelling the wax is left out but vulcanized latex must be employed.

To build up a coagulum deposit for prosthetic hands, we have obtained excellent results with a mixture of magnesium sulfate and ammonium chloride, which is held in place with casein. The following formula is prepared:

Part A	
Casein	3¾ ounces (97.5 Gm.)
Sodium borate	½ ounce (15 Gm.)
Beta naphthol	50 grains (3.2 Gm.)
Hot water (212 F)	16 ounces (473 cc.)

The casein is soaked in the hot water for ten minutes. Then the sodium borate is added and the mixture is stirred or shaken. The beta naphthol is then added while the mixture is being stirred.

Part B	
Ammonium chloride	7 ounces (200 Gm.)
Magnesium sulfate	12 ounces (340 Gm.)
Hot water	28 ounces (808 cc.)

The ingredients in part B are mixed together until they are in complete solution. If necessary more water may be added. Part B is then added to part A while the mixture is being stirred.

The coagulating agent is applied after the separating medium is dry. This is done by pouring the mixture into the mold, draining it out and then allowing the surface of the mold to dry. This produces a cast of sufficient thickness to be of practical value.

The casein holds the metallic salts in place so that they can have their action on the rubber latex when it comes in contact with the mold.

THE LATEX FORMULA

The latex formula which we have found to be the most useful for prostheses is composed of:

Vultex H222	50 g.
Vultex H222 part B	19 g.

However, this can be varied to suit specific conditions or can be compounded differently with the basic ingredients as desired.

To facilitate an even and undistorted deposit of rubber on the mold a container of hot water near its boiling point is prepared. A wire holder is then fixed around the open end of the hand mold. The mold is held over the container, and as the latex is poured into the mold it is allowed to sink into the hot water. This prevents distortion from ballooning. The wire retainer will eventually come to rest on the sides of the container. The hot water speeds the action of the coagulating agent on the latex which should remain in the mold for from one-half hour to one full hour, depending on the thickness of the deposit that is desired.

During this time a skin, or film of rubber will be built up over the opening of the mold. This must be removed with a pair of sharp, pointed scissors, the cutting being done about $\frac{1}{4}$ inch (0.64 cm) toward the center of the opening away from the surface of the mold. The mold is then removed from the hot water, and the excess latex is poured back into the container. The mold is suspended over the container until it ceases to drain. This takes about ten minutes.

If one looks into the mold at this point one will find there a coagulum deposit of rubber about $\frac{1}{8}$ inch (0.32 cm) in thickness. This is still wet and easily broken, so no attempt should be made at this point to remove the cast from the mold. Furthermore, the mold must now be handled with great care, because, should it be pressed or bent together, the inner surfaces of the cast will stick, and their separation becomes impossible without ruining the cast.

If the hand is not to be enlarged in the naphtha-liquid petrolatum mixture and is to be filled with wax for practical use, it is best to fill it at this point to prevent shrinkage. Also the hot wax has a toughening effect on the deposit of rubber. If this is not the case, both the mold and the cast are placed in the oven at 90 C for about a half-hour to dry or cure the cast. During this time the cast shrinks rapidly from the mold. The excess water in the cast runs free and will gather in the mold if it is suspended with the hand down or will drip from the mold if it is suspended with the hand up. Nevertheless, the cast gains in strength to a point at which it can be pulled from the mold. Before this is attempted, the mold is allowed to cool and talc is dusted within to prevent the inner surfaces from sticking together. It will be noticed that the cast is decidedly smaller than the mold. This is caused by the uniform shrinkage of the cast from the nonabsorptive surfaces of the mold on coagulating and drying.

If the cast is not completely dry, it will be observed that it is much lighter in color than dried rubber though rather opaque. This lightness can be preserved somewhat by soaking the hand immediately in the enlarging solution which is composed of

Oil free naphtha
Liquid petrolatum

8 parts by volume
2 part by volume

A flat vessel of sufficient size to allow for considerable swelling should be used. The vessel should be large enough to eliminate the possibility of the cast's touching any two opposite sides at the same time. If this happens the swelling rubber, which has become weakened, will probably break. Crowding of more than one cast in the solution should also be

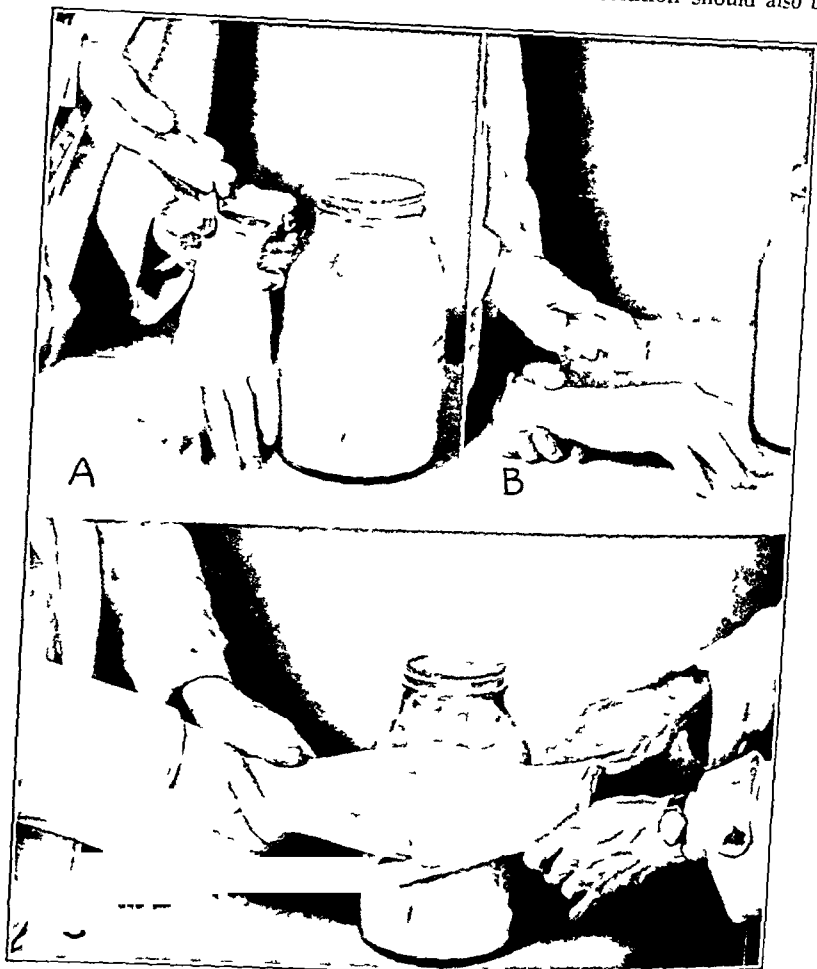


Fig 6—*A* the inside of the prosthetic hand while still encased in the mold is treated with talc to prevent sticking when pressed together. It will be noticed at this stage that the hand has shrunk from the mold. *B* the outside of the mold is also treated with talc so that the surfaces slide easily in the removal of the positive from the negative. *C* the cast is then pulled from the mold.

avoided. These precautions are important because of the extreme friability of rubber on reaching greatly enlarged proportions.

On removal from the solution the volatile naphtha evaporates leaving the cast impregnated with liquid petrolatum. On complete evapo-

ation of the naphtha the rubber cast regains its strength for rough handling. When the cast has become uniformly enlarged, it may be removed carefully from the solution and placed on clean blotting paper to dry. After twenty-four hours, it should have shrunk to its proper proportions. As stated before, the content of liquid petrolatum in the enlarging solution can be varied to change the size of the resulting prosthetic hand. In this manner, prosthetic rubber hands of various sizes can be made from the same pattern or donor. They may then be used for remolding for additional rubber and resilient resin prostheses.

III PROSTHETIC PLASTIC HANDS

The term 'plastic' has come to have a variety of meanings. In fact the meanings are so numerous that it becomes necessary to classify and

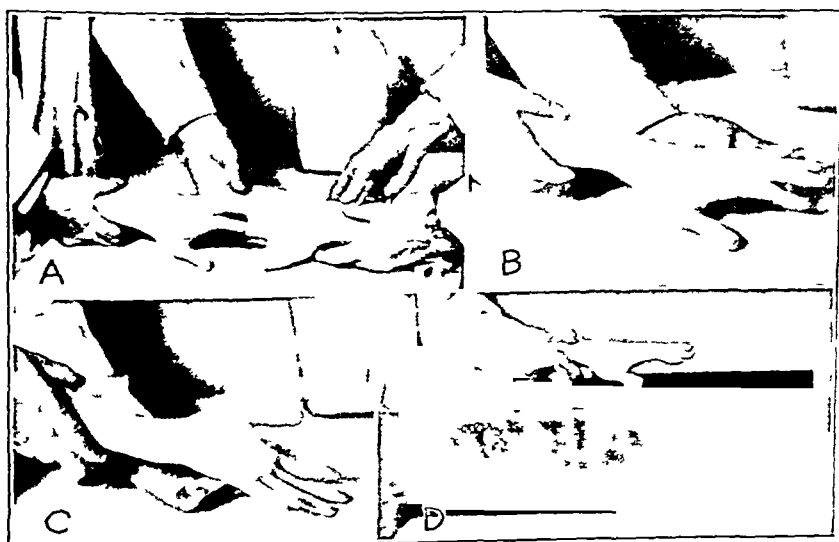


Fig 7—*A*, the hand finally emerges from the mold as the mold becomes inverted. *B*, the top surface of the rubber cast. It will be noticed that there are no seam lines. *C*, the palm side of the rubber cast. *D* the prosthetic rubber hand is placed in the naphtha-liquid petrolatum solution for enlarging.

condense them into the confines of prosthetic uses. The Latin word *plasticus* was taken from the Greek *plastikos* and used by the French as *plassein* and the English as "plastic." Its first meaning was to "form" or "mold." From it are derived such words as "plaster," "plasticize," "plastodynamia" and many others.

Among the meanings of the word 'plastic' are (1) giving form or fashion to a mass, formation, (2) causing or directing production or development, creative, as the "plastic" force of nature or plastic imagination, (3) capable of being molded or modeled as clay or plaster, hence

pliable, impressionable, (4) characterized by modeling, also, giving the effect of that which is modeled or sculptured, as "plastic" dancing, (5) in biology and surgery, that which is capable of undergoing metabolic transformation, formative, hence, pertaining to the growth, repair and transformation of tissues, as "plastic" lymph or "plastic" surgery, also, capable of structural adaptation to changing environment, as a "plastic" race or genus, and (6) in physics the capability of being deformed continuously and permanently in any direction, without rupture, under a stress exceeding the yield value

In the plastic-manufacturing industry, the term has a variety of meanings. For example, a plastic can be the material used or the product produced. It can mean the extent of bendability, softness, hardness or fluidity of the material or the product. For example, a house paint is made more "plastic," or fluid, by thinning. The term "resilient" is also at times interchangeable with "plastic." However, it generally means the ability of rebounding or springing back into its previous form.

Basically, the plastic industry is a branch of chemistry. One simplified but broad version of the origin of plastics is that they are derived from "coal, air, lime and water." If four more basic natural substances are added—petroleum, cellulose, sulfur and salt—nearly all the commercial types of plastics can be accounted for. Naturally, these basic materials must be subjected to numerous chemical changes before the resulting plastic is produced.

The first step in the manufacture of plastics is the synthesis of a large group of simple chemicals, such as ammonia, acetylene and hydrochloric acid. From these, the various reactive ingredients are synthesized. The manner in which the latter ingredients are combined to produce the final product varies with the type of resin. In general, resins are either condensation type (i.e., phenolic resins), which result from the combination of dissimilar organic chemicals to produce new compounds, or polymerization resins (i.e., vinyl or acrylic), which result from linking together of like molecules of the monomer to produce a resin of the same chemical nature but with different physical properties, called the polymer.

For the sake of convenience in a discussion of their preparation and properties, three categories of plastics are recognized. They are (1) thermosetting resins, (2) thermoplastic resins and (3) cellulose derivatives.

Thermosetting materials are those which harden when heat is applied. They must be formed relatively quickly in order to attain the desired shape before they become rigid. The five types of thermosetting resins are (1) phenolic, (2) urea, (3) melamine, (4) silicon and (5) unsaturated polyester resins.

Thermoplastic materials are those which can be repeatedly softened by heat and hardened by cooling. No chemical reaction is involved in the shaping of thermoplastic resins. This group of resins is comprised essentially of seven types. They are (1) nylon (2) alkyl (3) polyethylene, (4) styrene, (5) acrylic (6) vinyl and (7) coumarone.

Cellulose derivatives in general are thermoplastic in their behavior toward heat. There are a variety of cellulose esters and ethers generally classified in the following five types: (1) nitrate (2) acetate, (3) butyrate (4) ethyl and (5) regenerated cellulose.

We have found that nearly all the thermosetting thermoplastic and cellulose plastics in one form or another have been of use in prosthetic work. Furthermore their possibilities of use in the future of this field are unlimited. New materials or different applications of old materials are suggesting themselves in such rapid succession that by the time this article comes off the press it will be 'old stuff'. Nevertheless, to our knowledge, it is the first published data on the making of seamless prosthetic hands in any plastic.

Although thermosetting resins may have a limited use in prosthesis, those which are presently available do not lend themselves well to this application, consequently we shall be concerned purely with the thermoplastic resins. Of this type the acrylic and vinyl resins are the most popular.

ACRYLIC RESINS

The best known member of the group of acrylic resins is methyl methacrylate, which has its main prosthetic application in the making of dentures and artificial eyes because of its ready malleability, naturalness or similarity to human tissues when properly filled and colored. It is also relatively strong and is light in weight. Resins of this type are made from methyl and ethyl alcohols, acetone, hydrocyanic acid and similar chemicals. The reactions involved in the synthesis of the intermediate compounds are somewhat complicated.

VINYL RESINS

For the immediate purpose in mind, that of producing plastic prosthetic hands, the vinyl resins lend themselves admirably. For this reason they will be described in more detail.

Vinyl derivatives are basically those produced by the substitution of one of the hydrogens in ethylene by some other group. Thus the vinyl radical is $H_2C=CH-$. When a hydroxyl group replaces the hydrogen, the compound is vinyl alcohol. Analogously the compound containing chlorine is vinyl chloride and the compound containing an acetyl group is vinyl acetate. These are the three industrially significant vinyl derivatives. They are translucent, easily colored and readily plasticized.

into soft, pliable fleshlike resilient resins, which adapt themselves admirably to prosthetic work. A copolymer of vinyl chloride and vinyl acetate is also an important material for prosthetic use. In fact, it is the most important at the present in forming prosthetic hands. Derivatives known as polyvinyl acetals are produced by the reaction of aldehydes with polyvinyl alcohol, polyvinyl butyral made with butyraldehyde may be applied as a coating to fabrics. Another resin related to this group is polyvinylidene chloride, best known for its chemical inertness and its resistance to wear. The vinylidene radical is $H_2C=CH$, i. e., ethylene in which two hydrogens of one of the carbon atoms have been replaced by other elements or groups.

COUMARONE RESINS

The coumarone resins range from viscous liquids to high melting solids. Coumarone and indene obtained from coal tar are copolymerized in their production.

The great bulk of the products produced by the plastics manufacturers consist of molding powders. These powders are utilized commercially in the fabrication of all the familiar plastic items in every day use. However, this fabrication involves the use of elaborate equipment which compresses the heat-softened molding powder into molds under intense pressure. To withstand this pressure, the mold must be made of high quality, hardened steel and is consequently extremely expensive. This procedure is practical only when a great number of identical items are to be produced. Consequently, molding powders as such cannot be used for construction of prosthetic appliances.

While many attempts have been made to produce prosthetic hands in metal piece molds by hot injection and other forms of pressure, these have seldom been satisfactory. Pressure molding of such subjects invariably requires the use of cores, which in turn necessitates the making of piece molds or the complicated core perdué or lost wax process of mold making. The use of piece molds results in casts having seam lines, which are painfully obvious. In attempts to remove these seam lines on prosthetic casts, details of the flesh are lost to such an extent that the cure is worse than the disease. The resiliency and elasticity of modern plastics make it possible to cast them both in pliable molds, such as one piece rubber molds and rigid one piece electrotyped molds. The latter is important for mass production of prosthetic hands and will be discussed more fully in another article.

In seeking plastic materials suitable for the small scale production of prosthetic appliances, we are restricted to those which may be fabricated under laboratory conditions, without utilizing high molding pressure or extremes of temperature. Of even greater importance is the necessity of using temporary molds of plaster, rubber or similar materials. Although

there are a number of liquid casting resins on the market, these are for the most part thermosetting resins of the phenolic type, which are rigid and do not have the other characteristics, such as color, which are required to simulate flesh. Consequently, of the broad field of plastics, we are limited to a few.

The acrylic resins, of which the most important is methyl methacrylate, may be plasticized by mixing the polymer, ground to powder form, with the liquid monomer. The resulting dough may be compressed into molds and heat cured to yield a homogeneous product. This process is used to produce dentures and artificial eyes. As the resulting material is rigid, it is not suitable for other types of prostheses. The liquid monomer acts as a temporary plasticizer and does not impart a permanent flexibility to the acrylic.

The most suitable plastics for our purposes are those of the vinyl type. These may be combined with certain plasticizing agents, which give them a lasting flexibility without sacrificing too much tensile strength. Chemically the molecules of the plasticizer become interposed between the molecules of the resin polymer and thus provide flexible links in the otherwise rigid polymer chain of molecules. As plasticizing agents, a great number of substances may be used, usually of an oily nature. Among the most efficient for the vinyl resins are dioctyl phthalate, dibutyl sebacate, triethylene glycol and derivatives of ricinoleic or phthalic acids. However, for best results, the plasticizer must be intimately combined with the resin as a part of the manufacturing process. There are several plasticized vinyl materials on the market which may be used. One such material called Plastisol, is manufactured by the Bakelite Corporation, primarily for electrical insulation, however, the clear or transparent grade resilient resin is suitable for prosthetic work. It consists of a suspension of vinylite resin in a suitable plasticizer and comes in the form of a semiliquid or paste. The viscosity may be lowered by the addition of more plasticizer (this also increases the flexibility in the cured product at the expense of tensile strength). On heating to approximately 130 C the material cures by fusion of the ingredients. With proper filling and coloring, the appearance can be made similar to flesh.

Another product that has proved successful is sold under the trade name of Elastomer number 105 by the Electro-Technical Products Co (Nutley, N. J.). This material, which is shipped in liquid form, has considerable elasticity, resembling rubber in this respect. It has more strength than Plastisol and can be cured at lower temperatures. Elastomer is a viscous material with a 100 per cent solid content, which will cure and polymerize by the simple application of heat without pressure. It does not shrink or expand materially during the curing process and will take the finest details of the mold. While it resembles rubber in many characteristics, it is unusual in its resistance to most

solvents, including aromatic hydrocarbons, oils, acids, alkalis and water. It does not oxidize and harden on aging. It retains its flexibility even at extremely low temperatures, and it does not sustain a flame. It can be cured at lower temperatures than most plastics, which is advantageous when the fact is considered that rubber molds are used to obtain the plastic hands.

Its first drawback was that it was dark yellow on curing. However, by mixing with Plastisol and desensitizing pigments, this yellow color was overcome, and fleshlike prostheses of practical color and strength were obtained. Since these early experiments, the manufacturer has been so kind as to furnish us with a material which is lighter in color on curing. Elastomer is excellent for use in prosthetic hands, which must be stretched over mechanical devices to gain movement of the extremity.

PLASTICIZERS AND THINNERS

Plastisol, or the liquid form of polyvinyl plastics, is really a suspension of the vinylite powder in the proper plasticizers and thinning agents. This physical suspension does not become a homogeneous chemical mixture until heat is applied. While thinning agents may be classified as plasticizers for the purpose of this text, we wish to make a differentiation. We consider a thinning agent to be a volatile liquid which serves only to increase the fluidity of the ordinarily sluggishly flowing plastic, to facilitate ease in molding. In the curing process, it is completely volatilized, leaving no plastic effect on the product. A plasticizer may be considered an agent which plasticizes or softens the resulting cured plastic. In plasticizing with some plasticizers, the resulting product may lose in strength. In the making of prosthetic hands, it is necessary to use plasticizers which do not reduce the strength of the product beyond a certain point. In other words, in research along this line there must be a constant balancing of one quality against another at some cost to produce the final result. For example, sometimes strength must be sacrificed to a certain point to produce softness and vice versa.

The commercially prepared materials are apparently similar in nature to the materials mentioned previously but sold already filled and pigmented for prosthetic purposes. Flexiderm is marketed by the Nelson Kramer Corporation. Skin-tex³ and Di-Cor⁴ utilize a powder liquid combination. The directions given by the Vernon Benshoff Co. recommend that their material be mixed to a doughy consistency and then packed into plaster or synthetic stone molds. This method is suitable for most ear and nose prostheses but is not suitable for hand prostheses made in one piece rubber molds. However, we have been able to plasticize their powder into a suitable liquid for pouring into one piece

³ H. D. Justi and Son, Inc., Philadelphia

⁴ Vernon Benshoff Co., Pittsburgh

rubber and one piece metal molds. Furthermore, we found it to be compatible with Plastisol and Elastomer. By mixing various materials we were able to obtain any plasticity desired at no great loss to strength.

FILLERS AND COLORING AGENTS

Both Plastisol and Elastomer require some compounding before they are used. Indeed this is also necessary with Flexiderm, Di-Cor and similar products if the correct tone of the skin is to be duplicated. On curing, the raw or natural plastics Plastisol and Elastomer are almost transparent and slightly yellow. To these liquid materials we add a filler in the form of talc, zinc oxide, titanium dioxide, calcium carbonate or one of any number of other materials to reduce the translucency. The properly filled and colored materials on curing should produce a prosthesis closely resembling flesh in visual detail, translucency and color and should be the same to the touch. Good texture is obtained from properly made molds. The natural feel is obtained by good plasticizing. The correct translucency is achieved by the use of the suitable filler in the right amount. The proper color is obtained by the incorporation of pigments and dyes to produce a basic monochrome tint. For pigmentation cadmium red as a base color for fair skin and alizarin crimson for more swarthy complexions are recommended. Yellow is seldom used because yellowness may be achieved by slightly increasing the curing time.

The final toning (coloring) of the individual parts of the hand such as veins, knuckles and finger nails is blebbed or diffused into the plastic to such an extent that it will not be removed by washing or scrubbing. The basic coloring agents can be in the form of dry pigment, artist's oil color or oil-soluble dyes to resemble the basic flesh tones. Oil-soluble dyes in volatile solvents are used exclusively in the final toning or coloring. Of course, they should be chosen for permanency.

MAKING THE PLASTIC CAST

After the rubber mold is completed and removed from the donor, it is washed, while still reversed, with soap and warm water. Feather edges will be found in the mold where the rubber ran under the finger nails. It is best to cut them off with a pair of scissors. The mold is then turned back to its normal position by pushing the eraser end of a pencil into the fingers. The mold is allowed to dry thoroughly for a few minutes in an oven at about 75°C. It is now ready to receive the liquid plastic.

The previously prepared plastic should be kept in closed large-mouthed bottles, each bottle representing a slight difference in basic color. To the neck of each bottle should be tied a cured sample of the mix within the bottle. This is purely for matching against the patient's skin in choosing the proper mixture.

The mold is held beneath the bottle containing the plastic and a small amount of the compound is poured into it. This is seldom more than one third of its content. The mold is then grasped between the palms of both hands and rolled and rotated in massaging the mixture

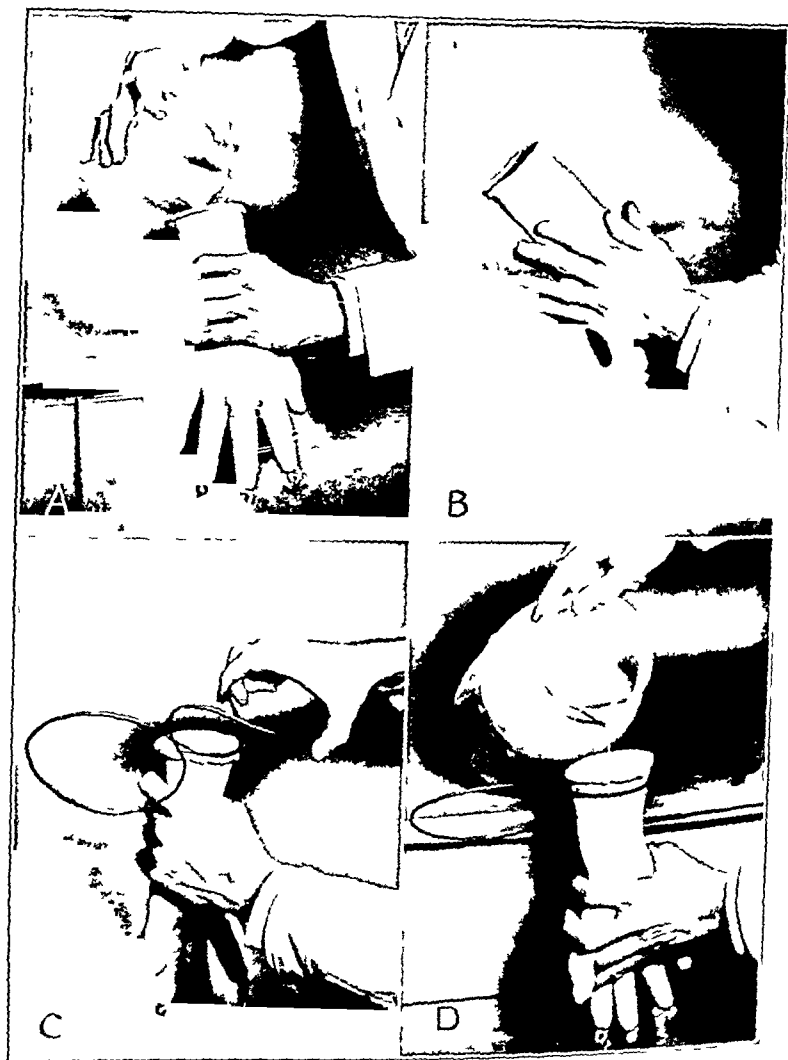


Fig 8—A the mold is poured half full of plastic. B, the mold is massaged to eliminate air bubbles. C the metal holder is placed around the open end of the mold. D the mold is filled with plastic.

over the entire inner surface. This is done to break the air bubbles that may form on the surfaces or within the mixture. The fingers should each receive individual attention because they are more likely to collect air bubbles and air pockets than the palms.

Before the mold is filled, a large straight-edged vessel of water is placed on the stove and started to boil. The water should come to

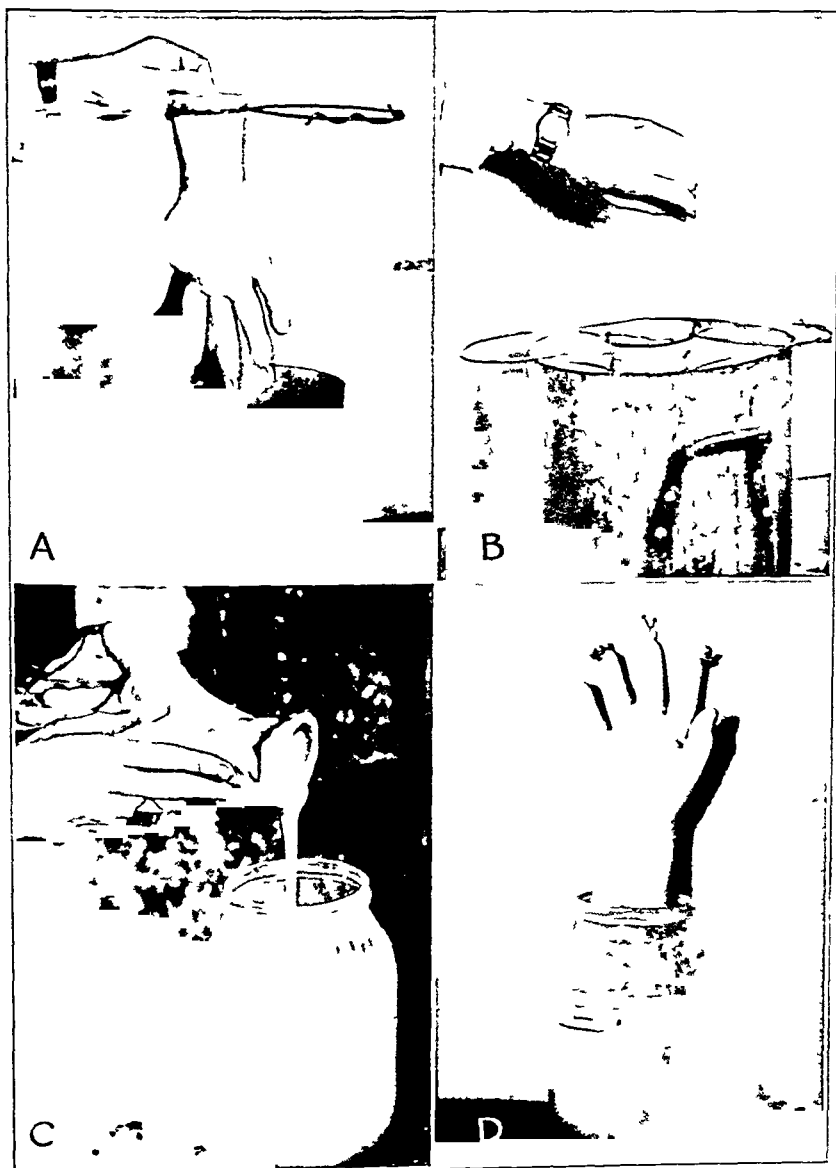


Fig 9—A the mold about to be lowered into boiling water. B filled mold is clocked in the boiling water to build up a deposit. C, surplus plastic is poured back into the jar. D, the mold is drained for three minutes.

within $\frac{1}{2}$ inch (1.2 cm) of the top of the container. Once it boils vigorously, the heat is turned down until only a slight movement takes

place This water will be used to build up an even deposit of the plastic on the inner surfaces of the mold

A metal holder, as seen in the illustrations, is also previously prepared Such metal holders can be made from heavy, soft, iron wire In fact, discarded wire suit hangers serve admirably for this purpose

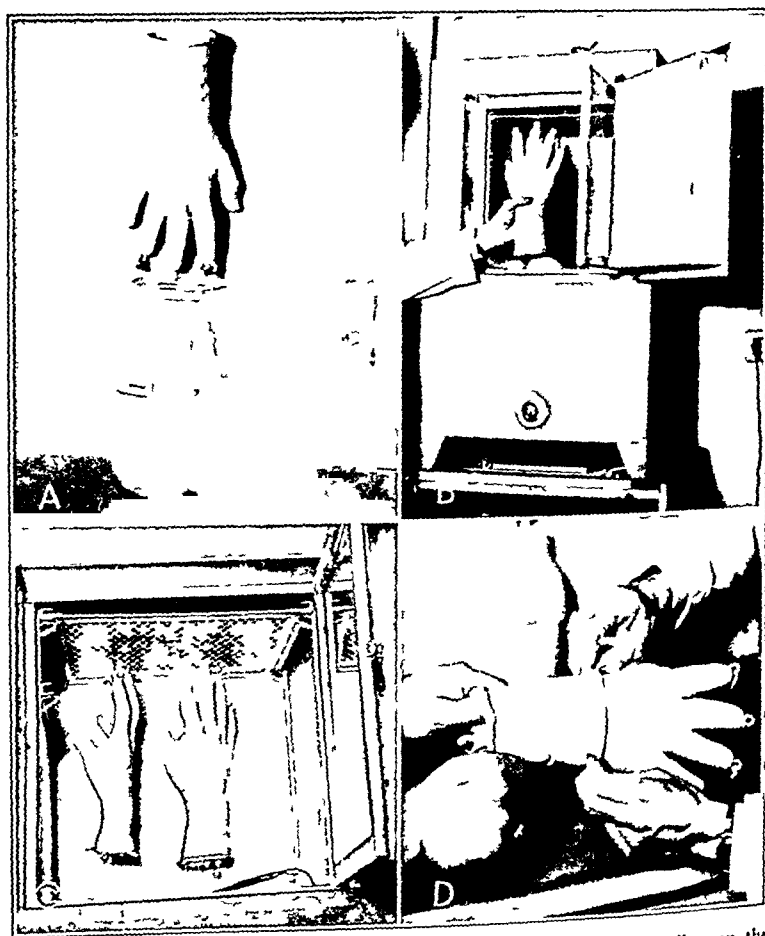


Fig 10—A, the mold is inverted and hung for two minutes, allowing the plastic to return to the finger tips B the mold is placed in the curing oven C, the molds are cooled in the oven before being removed D, the starting of the removal of the mold from the cast

when properly reshaped The metal holder is slipped over the wrist part of the mold Then the mold is filled with the plastic to within $\frac{3}{4}$ inch (19 cm) of the top

The filled mold is then lowered into the boiling water until the holder comes to rest on the edges of the vessel The moment the mold is placed

in the water notice is taken of the time, which is kept in seconds. The longer the mold remains in the boiling water, the thicker will be the deposit. This thickness of deposit also depends on the viscosity of the plastic. Thin or plasticized mixtures build up deposits more slowly. Thick or viscous mixtures build up deposits rapidly and have a tendency to become solid within the fingers. If the mixture is correct in viscosity, a uniform thickness of $\frac{3}{32}$ inch (0.24 cm) will be built up throughout, including the fingers, in forty-five seconds.

The mold is now removed from the boiling water and held with a dry towel to prevent burning the hands. The undeposited plastic is

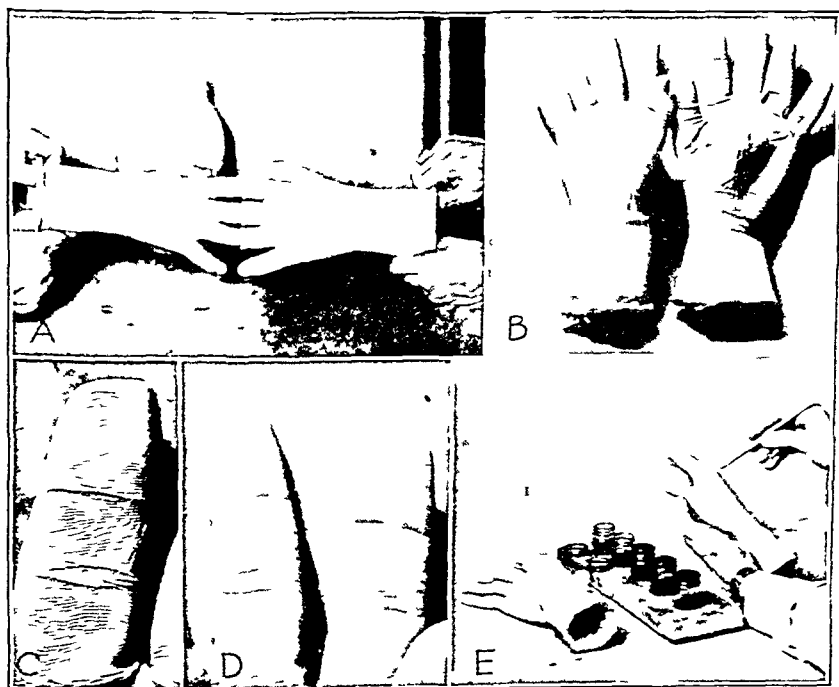


Fig 11—*A*, further emergence of the cast. *B*, the cast and reversed mold immediately after removal. *C*, enlarged detail on the finger of the reversed mold. *D*, surface of the fingers of the cast. *E*, the finished hand is painted.

poured back into the original container, care being taken to prevent the mold from collapsing. Should this happen, thin areas may appear where the inner surfaces of the cast touched. The mold can be hung by one of the rings on a finger and allowed to drain for about three minutes. The position is then reversed, the mold being hung by the wrist end for about two minutes. The purpose of this maneuver is to allow the sluggishly flowing plastic to continue to build up an even deposit and to prevent a collection of the mixture into one place. Fur-

thermore, this changing of position also increases the deposit on raised edges within the mold, which have a tendency to run thin

As the mold is moved to the curing oven the position is reversed again, and it is hung in the oven by the rings on the tips of the index and ring fingers. The cast within the mold is cured for fifteen minutes at 100 C. To the average worker who is accustomed to curing plastics in plaster of paris, synthetic stone and metal molds, this may seem to be a rather short time for curing. This results largely from the thinness of the rubber mold, the plastic deposit and the quickness of heat penetration. Temperatures and times in excess of those given should be avoided, since they cause distortion and rapid deterioration of the mold as well as darkening, drying, crazing and cracking of the cast. If Plastisol is used, it should not be removed from the oven until it has cooled to room temperature, as this material is easily cracked if it is bent while hot. Molds containing Elastomer should be removed from the oven while hot and repoured first on a slant to prevent the trapping of air. On cooling of the mold, the surplus is poured back into the jar and the mold drained for three minutes. It is then reversed and hung by the wrist for two minutes. The mold is now replaced in the oven and hung by the rings on the fingers and cured again for fifteen minutes at 100 C. In other words, the same process is repeated in an effort to build up thick uniform deposits. In fact, it may be repeated three or four times if desired, however, two times generally suffices for the average cast. The last baking can be done for twenty minutes at 100 C to insure thorough curing.

After the mold and cast have completely cooled the mold is dusted with talc to allow it to slip easily or invert on itself in removal of the cast from the mold. One person then grasps the cast while another grasps the mold, and the two are separated.

After removal from the mold additional sheen or lifelike appearance may be obtained by giving the cast a thin coat of castor oil and rebaking it alone at 70 C for fifteen minutes. This not only gives it a desirable sheen but increases its pliability or lifelike feel. We have also found that the cast can be materially strengthened by additional curing, effected by placing it in glycerin which has been brought to a temperature of 130 C and allowing it to remain there until completely cooled. Finally, the hand is colored with small brushes and oil soluble dyes, which bleed into the plastic, thereby becoming permanently incorporated into it. This process is described in detail in chapter IX of "Facial and Body Prosthesis" and will not be considered further here. In this chapter, the painting of rubber prostheses is discussed. The same technics and dyes are used for plastic prostheses.

5 Clarke, C D. Facial and Body Prosthesis. St Louis, C V Mosb Co. pany, 1945

THORACICOABDOMINAL APPROACH TO UPPER PORTION OF ABDOMEN AND UPPER POLE OF KIDNEY

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DENVER

THE DIAPHRAGM has always acted as a barrier to the progress of upper abdominal surgery. As a result the structures in the region of the diaphragm, such as the lower portion of the esophagus and the cardiac end of the stomach, have been neglected surgically. This is partly due to the fact that the chest itself was not opened up to surgeons until comparatively recently. However, even after open thoracic operations were made safe, the diaphragm remained a barrier, so that surgeons argued the advantages of the transthoracic versus the abdominal approach to diaphragmatic hernia. Obviously, if no harm would come from traversing the diaphragm it would be of tremendous advantage to be able to repair a diaphragmatic hernia with both the abdominal and the thoracic cavity open. The same applies to lesions of the lower part of the esophagus. In most of these lesions the site of the primary pathologic process is where the esophagus passes through the diaphragm. Here, again, the discussion has centered around the question whether it is better to approach the lesion from below or from above the diaphragm. Again, the ideal method is to dissect the diaphragm away from the esophagus and approach the esophagus at the site of the lesion. Lesions of the cardiac end of the stomach have been treated by total abdominal gastrectomy. This operation requires an unnecessarily wide resection below the lesion, but the resection stops at the diaphragm and so falls short of a complete resection above the lesion, where wide resection is most needed. If the diaphragm were opened, the shortcomings of total gastrectomy could be avoided. The spleen and the upper pole of the kidney are other organs which border on the diaphragm and have often presented difficult and dangerous technical problems because of the limitations imposed by the diaphragm.

In this paper I shall discuss the technical feasibility of traversing the diaphragm, I shall present an operative technic and show with illustrative cases, how such an approach has given a better understanding of some of the lesions encountered in the region of the diaphragm.

In 1941 I first had occasion to open the diaphragm and perform a combined thoracic and abdominal operation. The patient had a huge

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn. Dec. 7, 1946.

dumb-bell-shaped chondrosarcoma¹ arising from the seventh and eighth costal cartilages on the right side and traversing the diaphragm, approximately half the huge tumor being in the chest and half in the abdomen. To remove this tumor, it was necessary to split the diaphragm and remove part of the costal arch. I have recently reexamined this patient, five and a half years later, and found that she has had no difficulties resulting from this operative procedure.

The same year I had a patient with a traumatic diaphragmatic hernia. I debated whether to use an abdominal approach, for he was having symptoms of obstruction, or whether to use the more favorable thoracic approach. I used the thoracic approach, but on opening the chest I found that the diaphragm was split from the costal attachment through the esophageal hiatus, so that I really had a combined thoracic and abdominal approach. I found it easy to inspect and replace the abdominal organs. I have also seen this patient five years later, and he has had no difficulties resulting from the operation.

In 1942, while I was in the Army, Dr. Rubin Lewis, of Philadelphia, and I dissected a cadaver. We discussed the possibilities of approaching the upper part of the abdomen through the chest and worked out on the cadaver what we thought was the best incision. Soon after that I went overseas and had no opportunity to use the incision. However, since I have returned, I have employed this incision in a number of cases and have found it satisfactory. I shall present cases illustrating its usefulness.

TECHNIC OF OPERATION

The patient is placed on the operating table in a true lateral position, with the left side up. Endotracheal anesthesia induced with a nitrous oxide-oxygen-ether mixture is used. The incision is made over the ninth rib and extended from the angle of the rib to the anterior margin of the costal arch. The ninth rib, together with its costal cartilage, is removed subperiosteally and the thorax opened through the periosteal bed. The thoracic cavity is then explored, and any adhesions to the diaphragmatic pleura are divided. It is well at this time to divide the pulmonary ligament and crush the phrenic nerve. The costal arch is then divided and the edge of the diaphragm picked up to start the incision through the diaphragm. The diaphragm is then split from its costal edge to the esophageal hiatus. Rib spreaders are then inserted, which open the incision sufficiently to give adequate exposure to the structures from the pylorus of the stomach to the arch of the aorta. It is necessary to divide the peritoneal reflection from the cardia of the stomach and the lower end of the esophagus. At the completion of the operation the diaphragm is closed with two rows of interrupted cotton or silk sutures, and the thoracic incision is closed in the usual manner with interrupted cotton sutures. In most cases it is not necessary to use suction drainage, but in cases in which an anastomosis has been made between the stomach and the esophagus I think it is advisable. I have routinely used an oxygen tent for twenty

¹ Harper, F. R. Huge Chondrosarcoma Arising from the Chest Wall and Extending into the Thorax and Abdomen, *J. Thoracic Surg.* 11: 446, 1942.

four to forty-eight hours after operation. After that the patients are allowed to get out of bed, as I think early ambulation is advisable. None of them has had any postoperative difficulties.

Humphreys² described an abdominothoracic approach for carcinoma of the esophagus and the cardiac end of the stomach. He makes an abdominal incision and, after exploring the abdomen, turns the patient over and extends his incision into the chest through the eighth intercostal space. I prefer the incision I have described in that it eliminates turning the patient in the middle of the operation and avoids weakening the abdominal wall by the additional abdominal incision. Allison,³ an English surgeon, recently described an approach very similar to the one I have been using. Sweet⁴ used a thoracic approach for carcinoma of the esophagus and cardia of the stomach. He stated that when the exposure was not adequate he did not hesitate to divide the costal arch.

CARCINOMA OF THE CARDIA AND ESOPHAGUS

The most important lesion requiring adequate exposure of both the stomach and the esophagus is carcinoma of the cardiac end of the stomach and the lower end of the esophagus. An incision such as I have described allows for adequate resection of both the stomach and the esophagus and makes the anastomosis easier because it can be done under direct vision. It is easier to control bleeding, and the split diaphragm can be sutured to the stomach at the desired level.

CASE 1—Esophagogastrectomy for carcinoma of the cardiac end of the stomach. A white man aged 46 had noticed difficulty in swallowing for eight months prior to admission. He complained of increasing weakness and loss of approximately 30 pounds (13.6 Kg) of weight. After admission to the hospital he began to have tarry stools. Esophagoscopy examination was made, but the esophagoscope could not be passed into the stomach because of the lesion. Biopsy revealed adenocarcinoma. Through a thoracoabdominal incision the spleen was removed and the upper third of the stomach resected, together with the lower 2 inches (5 cm) of the esophagus. The cut end of the remaining portion of the stomach was closed. An elliptic opening was made in the wall of the stomach into which the esophagus was anastomosed. The diaphragm was sutured to the stomach just beyond the anastomosis. The patient made an uneventful recovery and three months after discharge from the hospital was eating solid food without difficulty.

I feel that this operation has distinct advantages over total gastrectomy in that the resection was more complete and that by leaving two

2 Humphreys, G. H., II. An Approach to Resection of the Esophagus and Gastric Cardia, *Ann Surg* **124**: 288, 1946.

3 Allison, P. R. Peptic Ulcer of the Esophagus, *J Thoracic Surg* **15**: 308, 1946.

4 Sweet, R. H. Transthoracic Gastrectomy and Esophagectomy for Carcinoma of the Stomach and Esophagus, in Bailey, C. P. *Diagnosis and Management of the Thoracic Patient*. Philadelphia, J. B. Lippincott Company, 1945.

thirds of the stomach the operation was more physiologic than it an esophagojejunostomy had been performed

CASE 2—Carcinoma of the stomach extending into the esophagus. A white man aged 58 had complained of burning pain in the epigastrium and difficulty in swallowing for about one year. He also had frequent coughing spells after meal. He had had occasional tarry stools and had lost 20 pounds (9.1 Kg) in weight. Roentgenograms showed extensive deformity of the outlines of the lower portion of the esophagus and the cardia. Through a thoracicoabdominal incision the upper third of the stomach and the lower 5 inches (12 cm) of the esophagus were removed, after removal of the spleen. The cut end of the stomach was

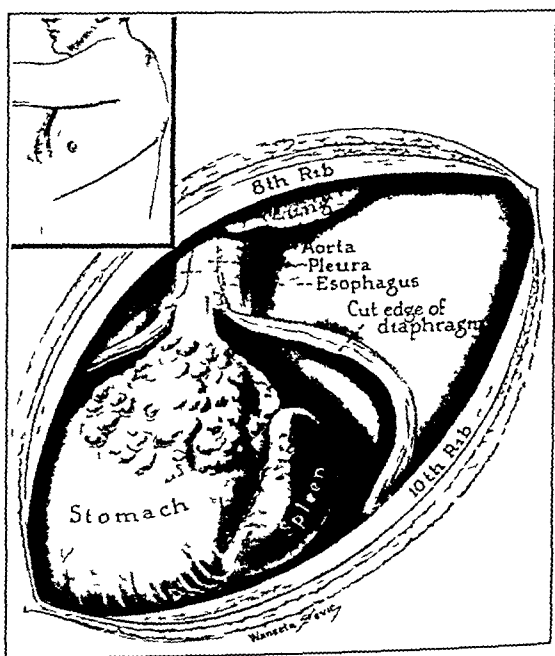


Fig 1—Artist's drawing illustrating the exposure obtained from the thoracicoabdominal approach

sutured and an elliptic incision made in the wall of the stomach into which the esophagus was sutured. The diaphragm was sutured to the stomach below the anastomosis. The patient was last seen seven months after his operation. His only complaint was slight difficulty in swallowing certain coarse food.

DIAPHRAGMATIC HERNIA WITH OBSTRUCTION

In some cases a large hiatal hernia of the diaphragm associated with vomiting it would seem desirable to explore the abdominal organ. Yet the abdominal approach to these hernias seems much more difficult and less advantageous than the thoracic approach. With a thoracicoabdominal approach the advantages of the abdominal and the thoracic approach are combined.

CASE 3—A white woman aged 39 for the past three years had had attacks of severe abdominal pain while lying down. These attacks of pain were accompanied with vomiting of undigested food. She obtained some relief by elevating the head of the bed. On several occasions she had persistent cramplike pains, which extended under the sternum toward her throat. On these occasions the pain lasted two to four days and then left suddenly. Operation was performed through a thoraciccoabdominal incision. On opening the chest about one third of the stomach was observed to be herniated through the diaphragm. The diaphragm was split to the hernial ring and the hernia sac dissected out. The stomach was then replaced in the abdomen and the abdomen explored. The cardiac end of the stomach was loosely sutured to the under surface of the diaphragm and the dia-



Fig. 2—Roentgenogram showing large diaphragmatic hernia

phragm closed around the esophagus. Since the operation there has been no return of the original symptoms.

CASE 4—A white woman aged 63 had complained of pain in the upper part of the abdomen and the lower part of the chest for ten years. The pain came on after eating solid food, and repeated attacks of vomiting had accompanied the pain. Operation was performed through a thoraciccoabdominal incision. On opening the chest, approximately one half of the stomach was observed to be herniated through the diaphragm into the chest. Operation was carried out in a manner similar to that in the previous case. Three weeks after the operation she had a slight stroke, from which she recovered rapidly. Her abdominal symptoms have disappeared.

DIAPHRAGMATIC HERNIA ASSOCIATED WITH PEPTIC ULCER OF THE ESOPHAGUS

CASE 5—A white woman aged 64 complained of pain in the upper part of the abdomen of four years' duration. She described the pain as coming on one half hour after meals and at night. It was frequently associated with regurgitation of gastric contents, which was so frequent as to cause severe glossitis. She had also had frequent tarry stools, as well as occasional vomiting of blood for four years. At the time I first saw her, she had had severe hematemesis, and, although she had had four blood transfusions during the week, her blood pressure was



Fig. 3—Roentgenogram showing hiatal hernia of the diaphragm associated with peptic ulcer of the esophagus. Note the inflammatory constriction of the lower end of the esophagus with dilatation above.

only 80 systolic and 40 diastolic. Her red blood cell count was under 3,000,000. Her weight had decreased from 200 pounds to 120 pounds (90.7 to 54.4 kg) in four years. She was placed on a regimen of 15 minims (1 cc.) of tincture of belladonna fifteen minutes before eating and 1 fluid drachm (4 cc.) of liquid petroleum just before eating and was given feedings every two hours while awake. The bleeding stopped and she improved considerably during the next two months. Roentgenograms showed a hiatal hernia of the diaphragm with narrowing and ulceration of the lower end of the esophagus. Esophagoscopy examination showed ulceration of the lower end of the esophagus. Biopsy revealed only inflammation.

tissue. Operation was performed, using a thoracoabdominal incision. On entering the chest, extensive adhesions between the lower lobe of the left lung and the diaphragm were observed. About one fourth of the stomach was herniated into the chest. On splitting the diaphragm, considerable inflammation was seen around the hernial ring, and the hernial sac was adherent to the surrounding structures and the esophagus. The esophagus itself was thick walled and inflamed. The esophagus was carefully dissected free and the stomach replaced in the abdomen. The abdomen was explored and the diaphragm then sutured around the esophagus after being first anchored to the cardia of the stomach. Since the operation the patient has had no return of her original symptoms or bleeding.

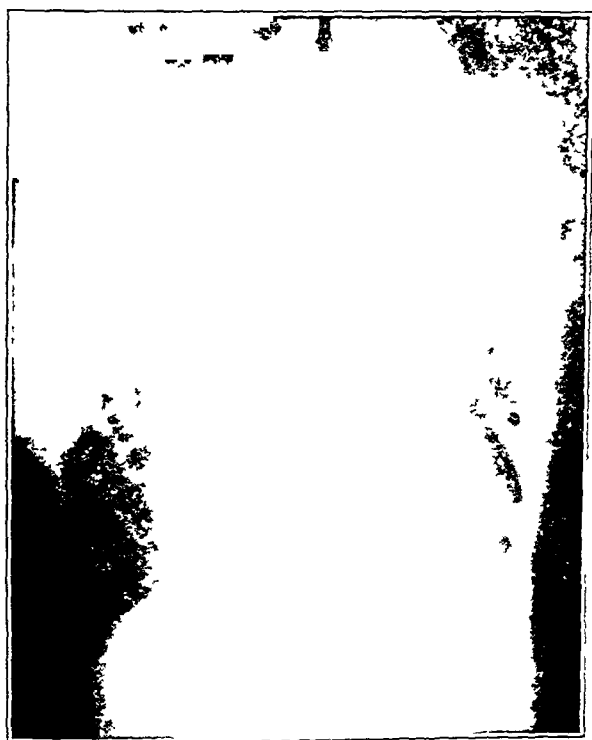


Fig 4—Roentgenogram showing enormous esophageal dilatation resulting from cardiospasm.

She has, however, complained of gas and a feeling of fullness in the left upper portion of the abdomen.

ACHALASIA OF THE ESOPHAGUS

CASE 6—A white man aged 63 gave a history of having had spells of being unable to eat for forty years. These spells would last about three weeks. Eight years ago he had a severe attack. At that time he was treated with esophageal dilations. For the past eight years he had eaten only strained foods. Six weeks prior to entering the hospital he had an acute exacerbation of his trouble and for the past six weeks had been unable to take even strained foods. If he took food

he would have a feeling of fullness in the chest and pain in the epigastrium. He would get some relief from induced vomiting. Esophagoscopy examination was attempted, but it was impossible to pass a tube or any dilating instrument. At operation a thoracoabdominal incision was made. The pleura was free. The pulmonary ligament was divided and the diaphragm split. As the incision in the diaphragm approached the esophageal hiatus, the muscles of the crura of the diaphragm were observed to be hypertrophied to at least twice the normal size. The esophagus was tightly surrounded by the crura, so that not even the tip of a finger could be inserted through the esophageal hiatus. However, when the crura were dissected away from the esophagus, there was no evidence of inflam-



Fig. 5—Roentgenogram of the kidney after injection of air to show tumor of the adrenal gland.

mation or scarring. The narrowed part of the esophagus extended for about 4 inches (10 cm) above the diaphragm. At this point I opened the stomach and inserted my finger into the esophagus. I was surprised to find that the esophagus was thin walled and that, even though the history was of forty years' duration and there had been repeated instrumentation, there was no evidence of scarring or thickening of the esophageal wall. Another interesting finding was that the esophagus was narrowed so that it admitted my finger with difficulty and that as the finger was introduced it was gripped by the esophagus. The feeling as my finger was pulled back and forth in the esophageal narrowing was exactly the

feeling one gets in making a rectal examination. With my finger still in place, I dissected down to the longitudinal muscles of the esophagus but this did not relieve the sphincter-like action. I then made an esophagogastric anastomosis and a jejunostomy and closed the diaphragm around the stomach near the anastomosis. After putting in an underwater drain, the chest was closed. The patient is now able to eat without difficulty.

COMMENT ON BENIGN LESIONS OF THE ESOPHAGUS

I have described cases of two types of nonmalignant lesions of the esophagus resulting in narrowing of the lower end of the esophagus with dilatation above. In the one type there is widening of the esophageal hiatus in the diaphragm with relaxation of the crura, so that the stomach is herniated into the chest. The esophagus is short, and the constriction is due to inflammation and ulceration. In cases of this type regurgitation of stomach contents especially with the patient in the recumbent position, is a prominent feature. Allison⁵ stated that ulceration results from the lower end of the esophagus being constantly bathed by acid from the stomach. Knight⁶ observed that after bilateral excision of the thoracic portion of the sympathetic chain there was diminished tone of the sphincters so that digital pressure on the abdomen readily returned the meal from the stomach to the esophagus. In these cases sympathetic control may be lacking.

In the other type, or achalasia, there is narrowing of the esophageal hiatus with hypertrophy of the crura of the diaphragm and increased tone of the esophageal sphincter. The esophagus is longer but there is no inflammatory reaction either in the wall of the esophagus or around the esophagus. Knight⁶ stated the belief that there is a sphincter of the esophagus but that the presence of an anatomic sphincter is extremely difficult to demonstrate and has frequently been denied. I felt that in the case I have described I could definitely say that there was a sphincter.

Jackson⁷ described a diaphragmatic pinchcock action in cardiospasm. Thus I also feel was demonstrated in my case. Both Knight⁶ and Ferguson⁸ found that bilateral vagotomy reproduced the clinical and roentgenologic pictures of achalasia. Knight⁶ relieved the obstruction produced by vagotomy by sectioning the sympathetic supply to the esopha-

5 Allison, P. R., Johnstone, A. S., and Rovee, G. B. Short Esophagus with Simple Peptic Ulceration. *J. Thoracic Surg.* **12**: 432, 1943.

6 Knight, G. C. The Relation of the Extrinsic Nerves to the Functional Activity of the Esophagus. *Brit. J. Surg.* **22**: 155, 1934.

7 Jackson, C. The Diaphragmatic Pinchcock in So-Called Cardiospasm. *Laryngoscope* **32**: 139, 1922.

8 Knight, G. C. Sympathectomy in the Treatment of Achalasia of the Cardia. *Brit. J. Surg.* **22**: 864, 1935.

9 Ferguson, J. H. Effects of Vagotomy on the Gastric Function of Monkeys. *Surg., Gynec. & Obst.* **62**: 689, 1936.

geal sphincter. It would seem, therefore, that achalasia of the esophagus results from loss of vagus control. The question arises in my mind as to whether the innervation of the crura and the control of the esophageal hiatus are entirely through the phrenic nerve.

APPROACH TO THE ADRENAL GLAND AND THE UPPER POLE OF THE KIDNEY

The last case, that of a 12 year old girl with an adrenal tumor, illustrates the possibilities of transdiaphragmatic approach to organs lying

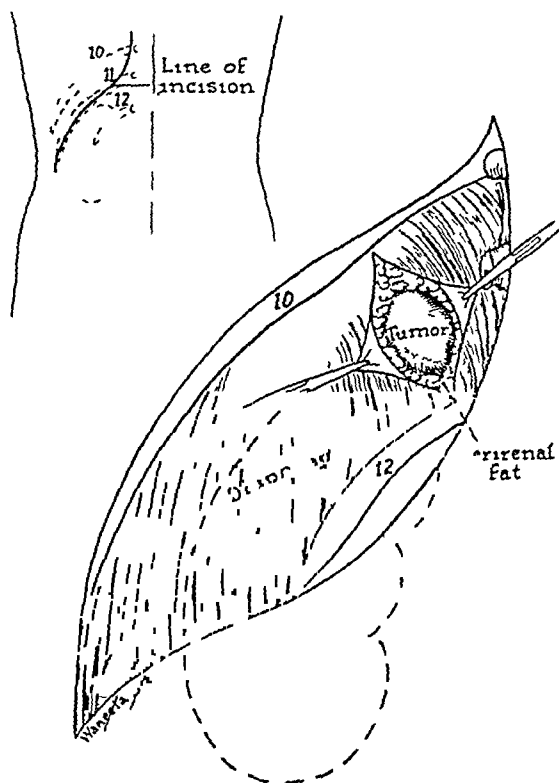


Fig 6—Artist's drawing illustrating transdiaphragmatic retroperitoneal approach to the adrenal gland and the upper pole of the kidney

below the diaphragm. The patient had the characteristic picture of Cushing's syndrome. Roentgenograms of the kidney after injection of air demonstrated a tumor of the adrenal gland about 2 inches (5 cm) in diameter. The child weighed nearly 200 pounds (90.7 Kg), making the abdominal approach seem difficult. The usual approach to the kidney would have necessitated considerable manipulation before the tumor could have been delivered. In manipulating such a tumor, there is

danger of rapid rise in blood pressure. For these reasons the tumor was approached from above. The eleventh rib was removed, the pleura opened and a 3 inch (7.5 cm.) incision made in the diaphragm retroperitoneally over the upper pole of the kidney. As soon as the diaphragm was opened the perirenal fat was encountered. When the fat was separated, the tumor presented at once. A ligature was placed around the pedicle of the tumor shutting off its blood supply, and the tumor was removed with no appreciable alteration in blood pressure. The approach to the adrenal gland and the upper pole of the kidney with a transdiaphragmatic, retroperitoneal approach is simple and practical.

ADVANTAGES AND DISADVANTAGES OF THE THORACICO-ABDOMINAL INCISION

The main advantage of the operation is that the exposure is much better than either the thoracic or the abdominal approach and it allows the surgeon to operate in both cavities at once. Being primarily a thoracotomy, it has the advantages of a thoracotomy over a laparotomy in that the patient can be carried in a lighter plane of anesthesia with less danger from infection of the respiratory tract or from embolism. The wounds generally heal more rapidly and are less likely to break down. On the other hand, a thoracic wound is more likely to be painful than an abdominal wound, and 2 of my patients complained of a feeling of fullness in the left upper quadrant of the abdomen. This was probably due to interruption of the phrenic nerve.

CONCLUSION

Structures in the upper portion of the abdomen can be approached easily and adequately through a thoracic incision if the diaphragm and costal arch are divided. The technical procedure is not difficult and the postoperative course is not complicated by the diaphragmatic incision. Cases of carcinoma of the cardia and esophagus, diaphragmatic hernia, peptic ulcer of the esophagus and achalasia of the esophagus have been presented to illustrate the usefulness of the approach. Unusual pathologic conditions around the esophageal hiatus have been encountered by dividing the diaphragm. It is felt that as more operations of this type are performed the pathologic and physiologic processes in the region of the esophageal hiatus will be better understood. A transdiaphragmatic retroperitoneal approach to the adrenal gland and the upper pole of the kidney has been used and found to be simple and practical.

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DISCUSSION

DR. JOSEPH W. GALE, Madison Wis. Dr. Harper has discussed the advantages and disadvantages of the thoracicoabdominal approach to the upper part of the

abdomen and has cited 6 interesting cases in which he employed this incision. He has spoken, correctly I feel, of the region of the lower part of the esophagus and the cardiac end of the stomach as the "no man's land in surgery." I shall not discuss the conditions for which this incision has been used but shall confine my comments to the approach. Several months ago, while discussing this problem with Dr. Harper, I stated that my colleagues and I had not used this approach, but that, if the occasion arose, we should certainly try it. Since then we have had several cases of diaphragmatic hernia and carcinoma of the lower end of the esophagus. In each instance only the thoracic approach was necessary. The only case in which the thoracoabdominal incision was employed was for the removal of a large adherent spleen. The technic in this case consisted of an incision in the eighth intercostal space, extending from the angle of the rib forward and downward through the costal margin. The exposure which was obtained was perfect, the operation greatly simplified and the patient's postoperative course uneventful. All realize that conclusions drawn from 1 case are based on too meager an experience to be of much value. In the past, we have had a group of thoracoabdominal cases in which the application of this approach would have simplified the surgery. Ordinarily, for thoracic operations we sacrifice a rib but in cases in which the incision also opens the peritoneal cavity we believe that an intercostal incision is preferable. The approximation of the thoracic wall is simple after the costal margin is sutured. The postoperative pain can be greatly reduced by crushing the neighboring intercostal nerves just anterior to the angle of the rib above and below the incision.

One must not overlook the added difficulties and possibilities of complications in this combined operation. If the thoracic cage is opened, respiration must be kept under control in order to have a clear view of the operative field. This demands an anesthetist who is well trained. Again there is the problem of reexpanding the lung and obliterating the dead space as rapidly as possible to forestall infection, atelectasis and pleural effusion. I believe that with the proper personnel this approach has advantages far greater than the abdominal approach. The casual operator, who does not see many cases with lesions in this region, finds it extremely difficult to expose this area. Through the use of the approach which Dr. Harper has described, exposure is much more satisfactory and the operator does not have to waste time and traumatize tissues, which is frequently the circumstance when the operation is attempted from below. Dr. Harper did not mention it, but I believe he will find that the site of the incision will vary depending on the habitus of the patient. In the pyknic patient it will probably have to be placed higher, whereas in the asthenic type it may be one or two ribs lower.

FUNCTIONAL SURVIVAL OF AUTOGENOUS AND HOMOGENOUS TRANSPLANTS OF BLOOD VESSELS

An Experimental Study

CARL S WILLIAMSON, M D *

AND

FRANK C MANN, M D

ROCHESTER MINN

THE FREQUENCY with which vascular injuries resulting from the war and from highway and industrial accidents are being encountered in everyday surgical practice indicates that all available knowledge of the poorly understood specialty of vascular surgery should be more widespread. It is this thought which leads us to believe that the experimental findings, about to be reported, are timely.

In this study we propose to invite attention again to some of the experimental observations that we have reported over a period of years as well as to new data on the subject of transplantation of blood vessels. A part of the data to be presented at this time has been published previously in connection with studies made in this laboratory on the autogenous and homogenous transplantation of the kidneys. The transplants of blood vessels necessary to accomplish the renal transplants were mentioned only casually as they applied to the other studies. Therefore at this time these studies will be reviewed again briefly, and the newer studies which have been made on vascular transplants per se will be presented in detail.

Over the past two decades the surgical prerequisites for successful vascular suturing have become so well standardized and known to surgeons who are interested in this procedure that they will not be described at this time. It will suffice to say that all operations in the experiments about to be reported, in which success depended to a great extent on vascular suture, were based on the original vascular suturing technic of Carrel¹ and of Guthrie,² with the addition of some modifications.

From the Division of Experimental Medicine, the Mayo Foundation

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn, Dec 7, 1946

* Formerly volunteer worker, the Mayo Foundation now on the staff of the Veterans Hospital, Albuquerque, N M

1 Carrel, A. The Surgery of Blood Vessels etc., Bull Johns Hopkins Hosp 18 18-28 (Jan) 1907

2 Guthrie C C. Blood-Vessel Surgery and Its Applications New York, Longmans Green & Company, 1912 p 120

which have been developed in this laboratory over a period of years. The literature on the technic of vascular surgery contains so many reports of successful vascular suture by surgeons from all parts of this and other countries that we seem justified in concluding that the general principles of this type of surgery are tested by time. A good functional result can be expected from vascular suture if the principles of the technic are followed carefully.

The vascular surgeon is confronted frequently with cases in which there is need of vascular repair as a result either of a major loss of critical vascular substance or of such severe damage to the vessels in the part as to render their use undesirable or impossible. In such cases the desirability of replacing the injured segment of vessel with normal structures from either the patient or a donor is great. Information on either type of these transplants is meager and inconclusive. The result is that, more often than not, the surgeon confronted with such a situation sacrifices the part by amputation, rather than take a chance on saving it by attempting a vascular transplant.

It is well established that tissues from one part of the body can be moved to another site and survive provided an adequate blood supply is available in the new location. When body tissues have been removed from one location in the body to another, as occurs in skin grafting for instance, the blood supply for the graft in the new location is dependent for survival on the infiltration of newly developed blood vessels. The term "transplantation," when used in contradistinction to "graft," means the movement of a body structure from one location to another in the same or another subject, with the reestablished blood supply in the new location. The blood supply in the new location is established in the cases of transplantation by uniting the major artery and vein of the transplant to suitable vessels at the host site. The term "homogenous transplant" indicates that the transplanted tissue or structure was taken from a donor and placed in another subject of the same species.

It is readily seen from this definition of a transplant that, in the light of present knowledge, not many body structures are available for transplantation. An organ such as the kidney is readily adaptable to such an operation, and so are sections of both arteries and veins. Vascular transplantation would be especially valuable if sections of normal vessels could be used to replace vessels which have been damaged as a result of trauma or disease. Thus many amputations might be avoided if the removal of a segment of a blood vessel from a highly vascular region to a region not so well supplied, because of damage to the normal vessels, could be relied on to meet the vascular needs of the injured part.

In earlier communications, one of us (C S W)² reported that after autogenous renal transplantation the kidney that had been removed

3 Williamson, C S. Some Observations on the Length of Survival and Function of Homogenous Kidney Transplants. Preliminary Report, *J Urol* 10

from its normal abdominal location to a new location in the neck of the experimental animal would sustain the renal health of the animal normally. In these experiments the renal artery and the renal vein were joined to the carotid artery and the jugular vein, respectively, by means of an end to end anastomosis. The ureter was disposed of by bringing it to the surface of the neck through a stab wound. The other kidney was removed, either at the time of the transplantation or within a short time after it had been done. In previous investigations Dederer⁴ had shown that an autogenous renal transplant would function satisfactorily. These results were confirmed and expanded by other investigators⁵.

Homogenous renal transplants, made in exactly the same manner as the autogenous ones, survived only a short time. However, immediately after transplantation and for a period of one to usually not more than seven days after operation, the two types of transplants responded to the same tests in essentially the same manner. But after a period of only a few days all the homogenous transplants ceased to function. During the functional life of the transplants the chemical composition of the blood of the animal was within normal limits, even though the normal kidneys had been removed. Histologic studies of the transplanted kidneys, after they had ceased to function, indicated that the failure came as a result of highly destructive nephritis. The destructive process involved both the glomeruli and the tubules of the kidney. Formation of a thrombus at the site of the vascular anastomosis was an infrequent cause of failure. In some instances the thrombus that was formed was associated with technical errors committed at the time of operation. Kinking and torsion of the vessels as a result of poor placement of the kidney in the neck at the time of operation were also an occasional cause of failure. Carrel and Guthrie⁶ reported the

275-287 (Oct.) 1923, Further Studies on the Transplantation of the Kidney, *ibid* 16 231-253 (Oct.) 1926

4 Dederer, C. (a) Studies in the Transplantation of Whole Organs. I. Autotransplant of the Left Kidney to the Neck with Right Nephrectomy in the Dog, *J A M A* 70 6-9 (Jan 5) 1918, (b) Autotransplantation of the Kidney, *ibid* 73 1836-1838 (Dec 13) 1919

5 Holloway, J. K. The Effect of Diuretics on Transplanted Kidneys, *J Urol* 15 111-131 (Feb.) 1926. Ibuka, K. Function of the Autogenous Kidney Transplant, *Am J M Sc* 171 407-420 (March) 1926. Function of the Homogenous Kidney Transplant, *ibid* 171 420-433 (March) 1926. Wu, P. P. T. and Mann, F. C. Histologic Studies of Autogenous and Homogenous Transplants of Kidney, *Arch Surg* 28 889-908 (May) 1934

6 Footnote deleted by authors

7 Carrel, A., and Guthrie, C. C. Successful Transplantation of Both Kidneys from a Dog into a Bitch with Removal of Both Normal Kidneys from the Latter, *Science* 23 394-395 (March 9) 1906

successful transplantation of kidneys from one animal to another. One of Dederer's⁸ homogenous renal transplants functioned for eighteen days. The earlier observers expressed the belief that failure in the transplantation of homogenous organs was due to technical difficulties, such as infection, formation of a thrombus or poor placement of the transplant. In the light of our own experiments which have been reported and those about to be reported, we may conclude that failure of the transplanted blood vessels per se was not often a decisive factor in the failure of the renal transplant to survive in the homogenous group.

The data to be reported at this time were obtained from (1) experiments on transplants of whole organs in regard to the function or lack of function, of the transplanted vessels and (2) experiments with the homogenous transplantation of blood vessels per se. Since the data on the first experiments have been reported in detail previously, as they apply to the survival and function of both types of renal transplants, this discussion will be limited to the observations that were made on the transplanted blood vessels. The data on the latter were mentioned, but not emphasized, in the earlier publications.

After the surgical technic had been established for the autogenous renal transplantation it was unusual for one of these experiments to fail. It was still more unusual to have one fail because of vascular defects which were secondary to the suture technic employed in establishing the vascular anastomosis. The most common cause of failure in experiments of this type came as a result of stenosis of the ureteral opening at the point of emergence from the stab wound in the skin. When the ureteral opening became stenosed, hydronephrosis, infection and pyonephrosis were sure to conclude the experiment within a relatively short time. The fact that the transplant was dependent for survival on a free and adequate blood supply and that this type of transplant did survive for an indefinite time seems ample justification for the conclusion that such a blood supply was present. Grossly, when the kidney was removed for histologic study, it was frequently almost impossible to determine the site of the previous end to end anastomosis between the vessels. Careful dissection of the vessels at the site of union revealed a minimal amount of deformity and scarring in both the artery and the vein. From these observations we felt justified in concluding that the autogenous transplantation of blood vessels, both artery and vein, could be undertaken with a reasonable expectation of a successful result. In order to obtain this result, however, great attention must be given to the details of the suturing technic as well as to the care afforded the vessels while the operation is in progress. Blood vessels about to be sutured cannot be allowed to become dry or be handled roughly if the repair is to be effective.

⁸ Dederer, C. Successful Experimental Homotransplantation of the Testis and the Ovary, Surg. Gynec. & Obst. 31:45-50 (July) 1920.

Homogenous renal transplants all failed to survive for any great length of time. After an operation of this type, which differed from the autogenous experiments only in that the kidney which was transplanted was taken from a donor animal and planted in the neck of the recipient, there was in the beginning little difference in the functional behavior in the two types of experiments. This similarity was of short duration. It lasted only for a few hours to a few days. During the time in which the transplant was functioning it would sustain the animal in a normal state of renal health if its own kidneys had been removed. But when the transplants ceased to function—and they all did after varying lengths

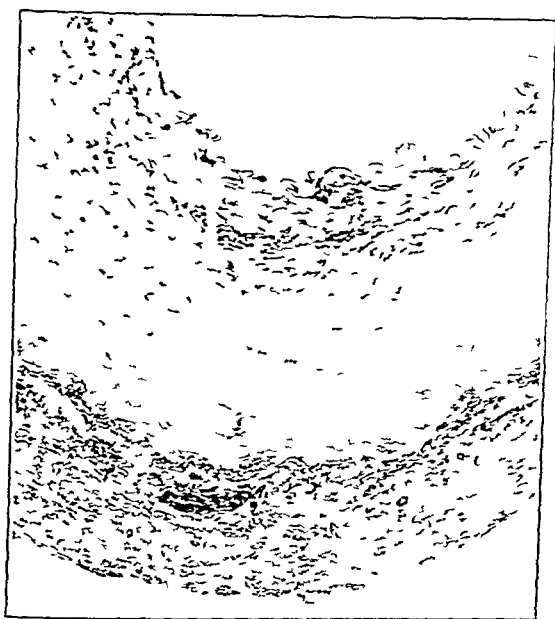


Fig 1—Wall of homogenous arterial transplant of fifty-six days' duration. Section was taken from region adjacent to the thrombus, $\times 75$. Compare with figure 4.

of time—symptoms of renal insufficiency developed and the animals died. The cessation of function in this type of transplant was so rapid that at first we believed it to be due to an accident, such as a thrombus, or possibly kinking, of the renal vessels. Further observations convinced us that the failure in most instances was biologic rather than mechanical in nature. It was only occasionally that the blood vessels were incriminated in the failure directly. The facts that after the kidney had ceased to function and had been removed for histologic study the blood vessels were more often than not in a good functional condition and further, that no other mechanical defects which might explain the failure could

be located lead us to believe that the agent in these failures was probably related to tissue specificity. This would explain why autogenous transplants would survive indefinitely whereas homogenous ones would survive for, at most, only a few days.

In view of these observations, it seemed to us that, since the kidney is a highly specialized structure and usually ceased to function while the blood vessels that supplied it were in a functional state, blood vessels, which are relatively simple structures, might survive for longer periods under similar conditions of transplantation. In order to determine this

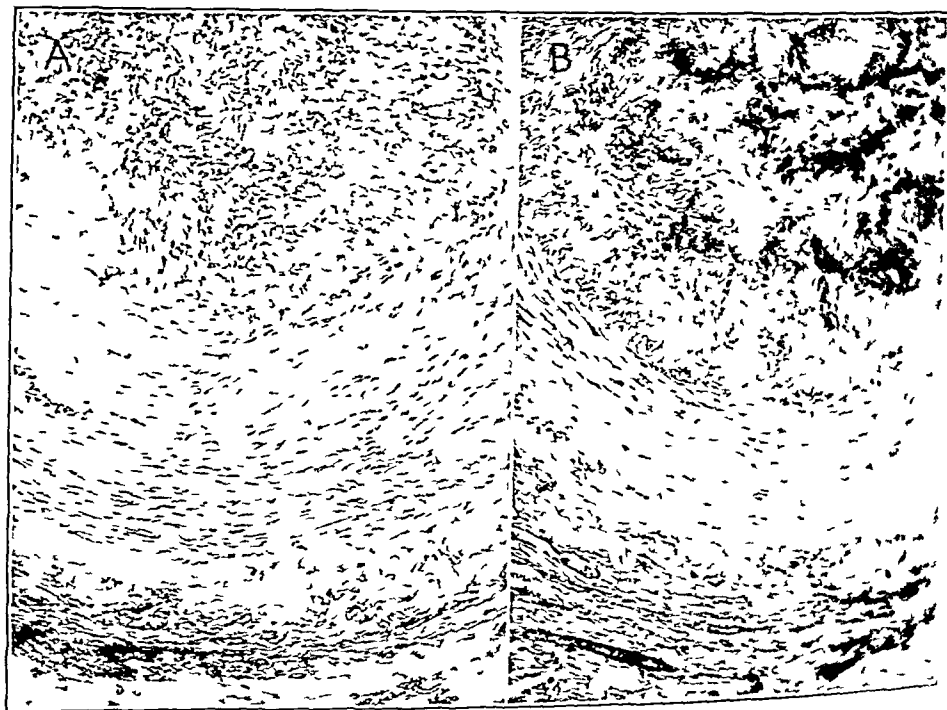


Fig 2—*A*, wall of artery and, *B*, wall of vein. In each case, the vessel was a homogenous transplant of fifty-six days' duration. Section was from region of the thrombus, $\times 70$.

point, a series of 6 medium-sized dogs were selected at random for the studies. This group of animals was divided into three pairs so that both animals in each pair would act both as a donor and as a recipient. With the animals under ether anesthesia and with the use of a deep technique, sections from the carotid artery and the jugular vein of each animal were removed and exchanged for similar sections removed from the same vessels of the other member of the pair. The sections removed were about 6 cm in length. Thus, at the conclusion

of the operation animal 1 had transplanted segments of the carotid artery and the jugular vein of animal 2, while animal 2 had similar segments of the corresponding vessels from animal 1. The transplanted segments of the artery and vein were allowed to remain in place for an elapsed time of fifty-six to sixty-two days and then were removed for histologic study.

OBSERVATIONS

On Dec. 11, 1945 segments of artery and vein were transplanted from animal 1 to animal 2 and from animal 2 to animal 1. On Feb. 5, 1946 the transplanted vessels were removed for histologic study. Grossly, there was no function in either the

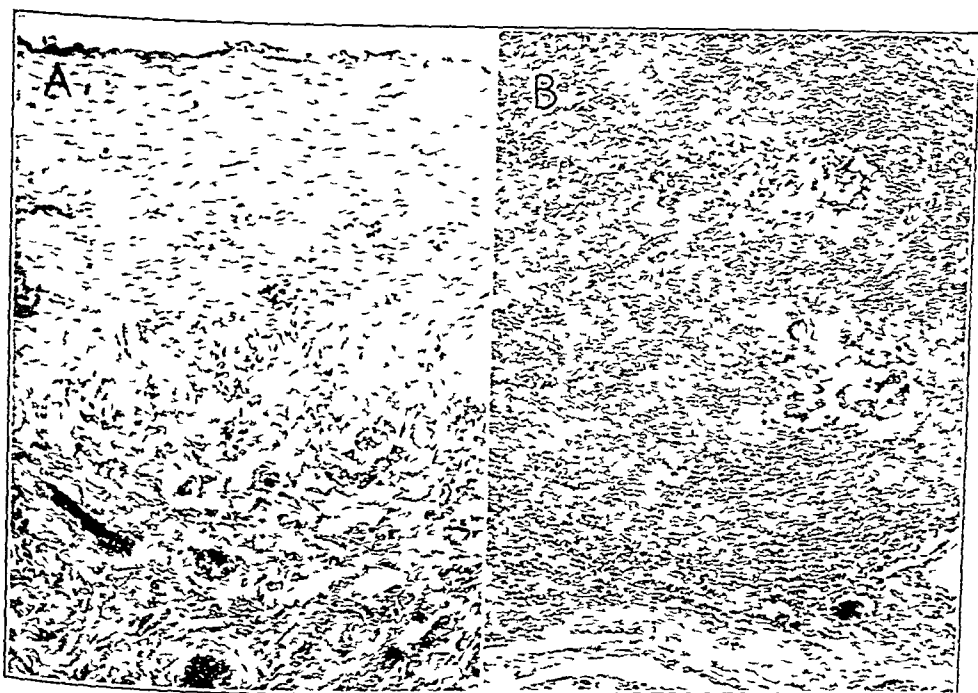


Fig 3—*A*, wall of artery, and, *B* wall of vein. In each case the vessel was a homogenous transplant of sixty-one days duration. Note vascularity in *A*. Sections from region adjacent to the thrombus. $\times 70$.

artery or the vein from animal 1. There was moderate inflammation around the operative site. Microscopically, the muscle fibers of the media of the artery were well defined. There was well defined development of capillaries between the intima and the media, with some of the capillaries extending between the muscle strands of the media. The cellular boundary between the intima and the lumen was poorly defined. The thrombus in the lumen was spongy and contained many sinuses filled with normal-appearing blood cells (fig. 1).

Grossly, there was no evidence of function in the transplanted artery and vein from animal 2. Microscopically, in the artery there were a few small capillaries between the muscle fibers of the media. Some capillaries extended through nearly the entire thickness of the wall. The intima was thickened and in some regions

had been replaced by fibrous tissue. The thrombus was spongy and contained many large sinuses (fig 2A). The vein showed simple thrombosis (fig 2B).

On Dec 5, 1945 segments of artery and vein were transplanted from animal 3 to animal 4 and from animal 4 to animal 3. On Feb 5, 1946 the transplanted vessels were removed. Grossly, there was considerable reaction about the operative site in animal 3. There was no evidence of function at this time. Microscopically, there was intense inflammation around the artery. The muscle fibers were fairly well preserved. The intimal lining of the artery was largely destroyed and replaced by fibrous tissue. The margin between the thrombus and the intima was poorly defined. The thrombus contained many capillaries (fig 3A). Few

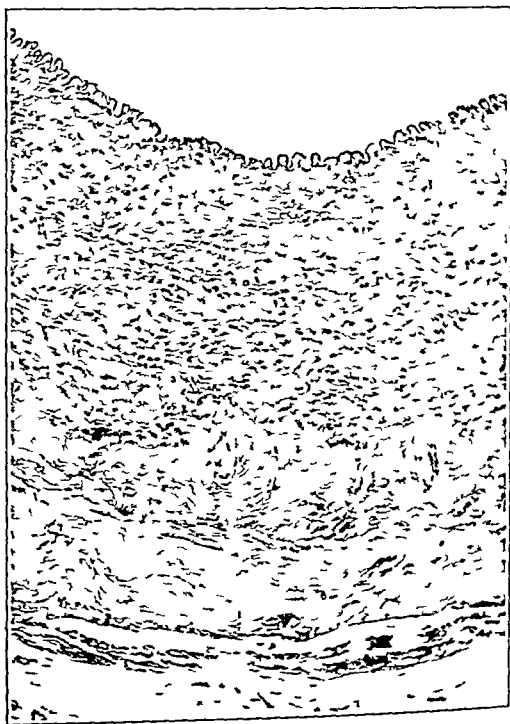


Fig 4—Wall of the carotid artery, which had been sutured and anastomosed in situ sixty-five days previous to removal. Section was taken from region adjacent to the anastomosis. $\times 75$

structures in the vein had survived. Intense inflammation was present. There was well developed sinus formation in the thrombus. The destructive process was much greater in the vein than in the artery (fig 3B).

Grossly, there was minimal reaction of the tissues at the operative site in animal 4. The artery was functioning, but the vein was thrombosed. Microscopically, there was intense reaction of the tissues with severe destruction of venous structures and replacement by fibrous tissue. The vascular walls had been invaded by extension of fibrous tissue from the thrombus. The thrombus was well organized and contained septums. There were many large capillaries in the wall of the artery. The intima was normal except in one region where there was a break of continuity, with the margins well defined. Around part of the arterial

ference of the lumen there was a densely adherent thrombus but this did not seem to have impeded circulation materially.

On Dec. 5, 1945 sections of artery and vein were transplanted from animal 5 to animal 6 and from animal 6 to animal 5. On Feb. 6, 1946 the transplanted vessels were removed. Grossly in animal 5 there were mild reaction in the tissues about the artery and more severe reaction about the vein. Neither vessel was functioning. Microscopically, the wall of the vein was much degenerated with replacement of normal venous structures by fibrous tissue. Some of the fibrous tissue extended into the thrombus which filled the lumen. The thrombus was divided by septums, in each of which were capillaries. In the artery there was very moderate replacement of normal vascular structures by fibrous tissue. The normal intimal outline had been obliterated. The lumen contained an extensive thrombus, which showed minimal formation of capillaries.

In animal 6 the gross tissue reaction around the transplanted vessel was moderate. Neither vessel was functioning so far as could be determined grossly. Microscopically, the arterial wall was well preserved with minimal replacement by fibrous tissue. In the lumen of the artery there was a thrombus which was well organized at the periphery but spongy in the central region. In this region there were many blood cells, suggesting that some function remained.

The carotid artery of animal 7 was sutured end to end. When the region of operation was examined grossly sixty-five days later, it was difficult to determine the site of suture, and the functional result was good. Microscopically there was no fibrous infiltration of the vascular walls. The intima had the normal serrated outline, and there was no evidence of formation of a thrombus (fig. 4).

COMMENT

Thus it is seen in the foregoing protocols that of the 12 operations 6 venous transplants and 6 arterial transplants, 10 had become nonfunctional after an elapsed time of fifty-six to sixty-two days. One arterial transplant was in a grossly functional state at the time of removal and another, the functional state of which could not be determined grossly, was observed to be functioning to a limited extent when examined histologically. All the venous transplants had ceased to function at the time of removal, and the remaining arterial transplants had also ceased to function. The results in 1 of the animals was compromised by a severe postoperative infection. Grossly there was nothing to account for the failure of the vascular transplants to survive. The histologic picture in both the arteries and the veins varied widely but was consistent in some respects in all the experiments.

The most common histologic feature in all thrombi in both arteries and veins was the tendency to vascularization in the thrombi which occluded the lumens of the vessels. This vascularization also included the walls of the vessels themselves. These new-formed blood vessels were in some instances fairly large and were evidently serving as conduits for a considerable amount of blood in both the arterial and the venous transplants. The thrombi which were present in the arterial transplants had in some instances a spongy appearance but those in the veins were

more solidly organized and there was a decided tendency for the clot to be divided into segments by fibrous septums

The destructive process in the arteries was less severe than in the veins, and there was also a greater tendency to canalization of the thrombi. In general the intima of the arteries was fairly well preserved, but in a few instances it had been largely destroyed and replaced by fibrous tissue. The muscle fibers of the media were also fairly normal in number and arrangement, but in some of the vessels in which the reaction had been severest many of the muscle fibers and much of the elastic tissue had been replaced by fibrous tissue. In summary, it can be said that the structure of the arterial walls of the transplanted segments of vessels had not been severely damaged except in a few instances.

Uniformly, the destructive process in the sections of the transplanted veins was complete. All the veins were thrombosed, and, while there was a tendency to vascularization of the thrombi, this process was not pronounced. The thrombi were more solidly organized and seemed to be more firmly attached to the walls of the veins than they were in the arterial transplants. The venous walls themselves were for the most part poorly preserved. There was extensive replacement of the normal mural structures with fibrous tissue, and in some regions this replacement was almost complete. An explanation of the severity of the reaction in the veins is not obvious. In all the transplants, both arterial and venous, there was a tendency to vascularization of the walls of the vessels, as well as of the thrombi which occluded the lumens. This characteristic was most pronounced in the arterial transplant. In some instances this development had progressed enough to be considered important as a channel for the arterial circulation. The status of these vessels in relation to the ultimate survival of the transplants remains a problem for future investigation.

SUMMARY

We wish to emphasize the following points:

1 The technic of vascular surgery is well established, and the surgeon who is willing to accept the requirements necessary for success in this work can expect satisfactory end results in the main.

2 The autogenous transplantation of both arteries and veins is a feasible surgical procedure in the light of present knowledge.

3 Homogenous transplantation of blood vessels, as well as other body structures, is not justified in the light of present knowledge.

4 There is a striking tendency for capillaries to develop in the thrombus and the wall of the vessel in homogenous vascular transplants. This tendency is most conspicuous in the arterial transplants.

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DISCUSSION

DR ERWIN R SCHMIDT, Madison, Wis It is with a feeling of some temerity that I come here to discuss this excellent paper, but I cannot let the opportunity pass without making some comments

First, this study probably represents the secret ambition of every clinician to do some basic scientific research At a meeting not long ago, it was pointed out to the clinical men that most of the basic scientific research underlying progress in medicine has been done by the doctors of philosophy, I did not want to argue the point, but I know that a great deal of such basic research has been done by clinical men

Second, it is the business of every clinical man to encourage and foster and to help people who are interested in this type of work I do not decri the clinical papers, for they are important, but in order for progress to be made this basic scientific work must be done

Third, the problem which the authors have presented has far reaching values in clinical medicine, applications which may not now be appreciated It is related to the problems of hypoxia Many years ago pathology was of the virchowian gross type, and so gross that almost any one could make the diagnosis The science has made great progress, and now one is concerned with minimal pathologic changes In other words, the physician is making an earlier diagnosis is being more careful and is giving the patient much better service

I feel that the problem of the reaction of tissue to lack of oxygen has to some extent been overlooked by all members of the medical profession Only in the last ten years has it come to their attention

I told Dr Williamson that I felt his problem in vascular transplantation was related not so much to the mechanics of the anastomosis, although this is important, as to the question of hypoxia and, more than that probably of anoxia

As to specificity of tissue response, it is known that the various tissues in the body may suffer in varying degrees from lack of oxygen, for instance, certain types of brain cells will be injured much more severely than others

For example, in the kidney, there are differences in reaction in the glomerulus and the ascending and descending portions of the tubule Therefore postmortem examination reveals many pathologic changes which can be interpreted as the effect of lack of oxygen on a particular tissue Comparable changes can be seen in the liver as a result of want of oxygen The liver has such tremendous reserve that the surgeon can go on with his procedures and have little idea of the functions of this organ or of what strain he can put on it Thus it is these minimal reactions which should be investigated, and I think this paper is an excellent attempt at such a study

The question of the susceptibilities of the brain and kidney have been studied, and the observations incorporated into clinical experience It has been only within the last few years, as a result of Brooks's work on gangrene, that the entire concept of the handling of inflammations has been changed In cases of senile gangrene, instead of elevating the extremities one now keeps them flat It is known that by keeping the limb level the venous pressure is increased and this raises the capillary pressure

It is known furthermore that if the temperature is reduced locally there is more chance of that tissue surviving The basal metabolic rate is depressed, and the oxygen brought there is sufficient to carry the tissue over the trying period These are observations which have been adopted in clinical medicine

There is a great demand for such investigations at the present time because of the recent large amount of trauma Vascular surgery is important in case of

trauma, and great advances have been made during the war. For instance, early surgical intervention in cases of arteriovenous aneurysm results in trouble, and so one waits until collateral circulation has developed. If operation is performed early, the blood supply is insufficient, there is a lack of oxygen, and gangrene intervenes. If one waits until collateral circulation has developed, one has sufficient blood supply and adequate oxygenation, and the limb will survive.

As a result of the work done in this country—and done by clinical men among whom are Blalock, Blackmore and, recently, Potts, of Chicago—notable advances have been made in vascular surgery. After listening to this paper by Dr. Williamson and Dr. Mann, I feel that one may look for further advance in surgery of the circulatory system.

DR. CARL S. WILLIAMSON, Albuquerque, N. M.: I want to thank Dr. Schlemmer for his discussion of this paper. He has given me some ideas which I shall take home and try to follow through. I might say that no one was more surprised than we at what we found in these experiments.

Because of our previous experience with homogenous renal transplant we felt that it was only a matter of form to make these experiments and confirm the assumption that all the transplants would cease to function within a very short time.

However, owing to the fact that of 12 transplants, 2 were functioning after a considerable period, we now wonder whether we took the transplants out too late or too early. In other words, we wonder what would have happened if we had left them in for a longer time and, also, what would have happened if we had taken them out earlier. We hope to find the answer to these questions in a future study.

BLOOD IODINE STUDIES

VIII The Blood Iodine in Nonthyroid Disease

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AND

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THE LEVEL of the blood iodine has been widely recognized as a valuable diagnostic aid in differentiating thyroid from nonthyroid disease. Consequently it becomes of importance to determine whether or not blood iodine values ordinarily deviate from the normal in diseases other than of the thyroid gland. Moreover, it is necessary to learn the degree of deviation as well as the nature of the pathologic states in which such variations may occur. Too, any abnormality in the level of the blood iodine in nonthyroid disease might suggest that the thyroid gland was either primarily or secondarily involved.

In contrast to those involving the thyroid gland, nonthyroid diseases in general affect the basal metabolic rate less characteristically¹ and even more seldom cause an increase or decrease of the blood iodine. This was revealed by an investigation of representative patients with one hundred and fifteen different nonthyroid diseases (tables 1, 3 and 4). Moreover, deviations of average blood iodine values from normal were, with one exception, increases (table 1) and were not necessarily accompanied by any apparent increase or decrease of the basal metabolic rate.

HEPATIC AND BILIARY DISEASE

In 11 patients with chronic cholecystitis, accompanied in all but 2 by cholelithiasis, the average blood iodine was significantly elevated, even in the face of a normal average basal metabolic rate^{1b}. Moreover, the elevation was commensurate with that found in patients with toxic goiter² (tables 1 and 2). The two lowest values for blood iodine in

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Aided by a grant from the Comly Fund for Research of The Ohio State University.

1. Curtis, G. M., and Fertman, M. B. (a) Blood Iodine Studies. VII. The Basal Metabolic Rate and Its Relation to the Blood Iodine in Thyroid Disease. *Ann Surg.*, **122**: 963, 1945. (b) IX. The Basal Metabolic Rate and Its Relation to the Blood Iodine in Non-Thyroid Disease, to be published.

2. Curtis, G. and Fertman, M. B. Blood Iodine Studies. VI. An Analysis of the Blood Iodine in Thyroid Disease. *Arch Surg.* **50**: 207 (April) 1945.

TABLE 1—The Average Blood Iodine in Nonthyroid Disease Plus or Minus the Standard Error Compared With That in Hyperthyroidism

Clinical Diagnosis	Chromium Trioxide ¹² Method		Dry Ash Method ¹¹	
	No.	Micrograms/ 100 Cc.	No.	Micrograms/ 100 Cc.
Normal persons	39	4.2 ± 0.2	16	11.9 ± 0.5
Diabetes mellitus	3	4.5 ± 0.7	3	7.6 ± 0.5*
Endocrine imbalance	3	3.7 ± 0.4	1	19.0
Pituitary dwarfism			2	7.3 ± 0.5
Acromegaly	2	3.2 ± 0.1		
Hirsutism	5	3.8 ± 0.4		
Hypopituitarism	4	4.8 ± 0.6	2	10.5 ± 0.2
Fröehlich's syndrome	2	6.2 ± 1.1*		
Addison's disease	2	5.0 ± 0.5	2	8.0 ± 2.6
Mongolism			8	15.1 ± 1.6
Obesity	15	4.1 ± 0.3	4	3 ± 1.3
Menstrual disturbance	6	4.1 ± 0.5	1	11.2
Chronic cholecystitis	11	7.0 ± 1.0†	2	13.0 ± 1.3
Mixed group of hypertensive conditions	14	5.1 ± 0.7	14	11.0 ± 1.4
Nonhypertensive cardiac disease	4	4.4 ± 0.4	3	13.5 ± 1.5
Aortic aneurysm	2	3.7 ± 1.2		
Chronic nephritis	2	4.1 ± 0.5	1	9.5
Secondary anemia	1	3.7	3	10.1 ± 1.5
Agranulocytosis			2	19.6 ± 0.3
Myelogenous leukemia	3	4.4 ± 0.6	6	14.0 ± 2.5
Lymphatic leukemia				
Men			2	19.2 ± 1.2†
Women			3	8.6 ± 1.7
Hodgkin's disease	2	3.9 ± 0.5		
Splenomegaly of undetermined origin	2	4.1 ± 0.9		
Benign tumors	12	3.7 ± 0.4	1	8.7
Extrathyroid carcinoma	2	3.7 ± 0.3	4	10.1 ± 0.9
Syphilis †	5	5.6 ± 1.1*	2	8.7 ± 1
Pulmonary tuberculosis	4	4.4 ± 0.3	7	10.4 ± 3.6
Tuberculosis of vertebra			2	14.5 ± 7.3
Cervical lymphadenitis	2	4.3 ± 1.4		
Empyema thoracis			2	16.1 ± 5.2
Bronchiectasis			3	11.5 ± 4.6
Sinusitis			3	10.7 ± 0.7
Mixed group of arthritic conditions				
Males	6	5.3 ± 0.5*	1	11.0
Females	9	4.1 ± 0.3	1	12.5
Pelvic inflammatory disease	3	5.2 ± 0.6		
Endocervicitis			2	15.6 ± 7.7
Colitis	3	3.5 ± 0.7		
Migraine	9	4.0 ± 0.5		
Fatigue			3	13.0 ± 4.7
Functional disturbance	26	4.0 ± 0.1	4	9.2 ± 1.2
Vagotonia	2	3.2 ± 0.5	1	9.3
Globus hystericus	3	5.5 ± 0.5		
Neurasthenia	8	4.0 ± 0.6	1	12.6
Psychoneurosis	17	4.0 ± 0.3	2	12.6 ± 5.5
Mental deficiency	2	4.2 ± 0.5		
Epilepsy	3	3.3 ± 0.2		
Allergy	4	5.3 ± 1.0		
Thyroglossal fistula			2	4.5 ± 1.5
Hernia	8	3.9 ± 0.3	3	5.3 ± 1.5
Fractures	4	3.5 ± 0.2		
Toxic nodular goiter	29	7.9 ± 0.8†	28	15.8 ± 1.1
Exophthalmic goiter	41	9.3 ± 0.6†	22	17 ± 1.1

* Significantly different from normal (chances better than 20 to 1)

† Highly significantly different from normal (chances better than 100 to 1)

‡ In 2 of the 5 syphilitic patients in the chromium trioxide group an endemic hepatitis was also recognized

this group, both low normal, occurred in the 2 patients without cholelithiasis. In the single patient with obstruction of the common duct the blood iodine was high but neither exceeded all other levels in this group nor was to any extent comparable with the tremendous values³ found by De Courcy.⁴

Elevation of the blood iodine in disease of the liver or of the biliary tract is of especial interest because of the important role the liver presumably plays in iodine metabolism,⁵ a role relegated by De Courcy specifically to the Kupffer cells.⁶ It has been shown that the iodine content of the bile is consistently high—so high in fact, that this con-

TABLE 2—The Average Blood Iodine Values Which Differ Significantly from Normal Together with Their Corresponding Basal Metabolic Rates Compared with Those in Hyperthyroidism

Clinical Diagnosis	Average Blood Iodine Chromium Trioxide Method ¹		Average Basal Metabolic Rate Dry Ash Method ¹²		
	No.	Micrograms /100 Cc	No.	Micrograms /100 Cc	%
Normal persons	39	4.2	16	11.9	-5
Diabetes mellitus	3	4.5	3	6*	-1
Fröehlich's syndrome	2	6.2*	2	2	-15
Chronic cholecystitis	11	7.6*	2	13.0	-2
Syphilis ‡	5	5.6	2	8.2	-2
Hypertension					
All	14	5.1	14	17.0*	
Males					-2
Females				6	-12†
Arthritis				11	-5
All					
Males	6	5.3*	1	15.0	
Females	9	4.1	1	12.5	
Lymphatic leukemia					
Males			2	19.2†	-74†
Females			3	8.6	-19†
Toxic nodular goiter	20	7.9†	28	15.5*	-28†
Exophthalmic goiter	41	9.3†	32	17.7*	-10†

* Significantly different from normal

† Highly significantly different from normal

‡ Two of the 5 syphilitic patients in the chromium trioxide group also had arsenical hepatitis

When there is a significant difference between males and females the two values are listed separately

3 Our own observations would lead us to think that these were due to recent administration of iodine, most likely the gallbladder dye with its high content of organically combined iodine.

4 De Courcy, J. L. Iodine Metabolism Normal and Abnormal Its Relation to the Reticulo-Endothelial System *Tr. Am. A. Study Goiter* 1937, p. 133

5 Elmer, A. W. Iodine Metabolism and Thyroid Function London Oxford University Press, 1938, pp. 190 and 194

6 De Courcy, J. L. Further Study of Blood Iodine Changes in Affections of the Gallbladder, *Surg., Gynec. & Obst.* 65:180 1937

7 (a) Libecap, I. L. The Iodine Content of Normal Human Tissues Thesis Ohio State University 1942 (b) King, J. D. The Iodine Content of the Normal Thyroid Gland Correlated with Its Histology and the Iodine Content of Other Normal Body Tissues Thesis ibid 1940

centration is second in the human body only to that in the thyroid gland and in the hair^{8a}. When the liver has been damaged, as in the hepatitis accompanying chronic cholecystitis or in certain other diseases the blood iodine has been noted to increase, often attaining levels even higher than those found in patients with hyperthyroidism⁸. De Courcy observed average concentrations of iodine in the blood ranging to one hundred times the normal level in patients with cholecystitis and cholelithiasis,⁴ also occasionally in patients with carcinoma of the liver^{8b}. He found levels up to one thousand times normal³ in patients with obstruction of the common duct⁴. Lesser elevations were noted in acute cholangitis,⁴ in hydrops of the gallbladder^{8b} and in carcinoma of the gallbladder⁴. De Courcy was unable to explain why the iodine content of the blood in patients with portal cirrhosis was found normal⁹.

Different results were obtained by Cohn and Feldman, who could find no elevation of the blood iodine level in 4 patients with various diseases of the gallbladder and the liver. From this and from the observation that carbon tetrachloride, a substance producing degeneration of hepatic cells, produces no significant change in the blood iodine of rabbits, they concluded that the functional relationship between the thyroid and the liver is not expressed by the blood iodine level¹⁰.

CARDIOVASCULAR AND RENAL DISEASE

Investigation of the blood iodine in patients with hypertension, together with the basal metabolic rate, is likewise of especial importance because of the occasional need to differentiate this disease from hyperthyroidism. Unfortunately, in this study as well as in others reported in the literature, it must be assumed that the clinical diagnosis of hypertension without hyperthyroidism was in all instances correct.

The average iodine level for whole blood, as well as the basal metabolic rate, was significantly elevated in one group of 14 patients with hypertension and hypertensive heart disease. These levels were determined by the dry ash method¹¹ (tables 1 and 2). In a subsequent group of 14 hypertensive patients, whose blood iodine was determined

8 (a) Footnote 4 (b) Iodine Content of Blood in Cholelithic Disease Arch Surg 35 140 (July) 1937

9 De Courcy (footnotes 4 and 6)

10 Cohn, A, and Feldman S E The Relation Between the Liver and the Thyroid Gland I Blood Iodine as an Indicator of Liver Function Am J Clin Path 12 27, 1942

11 Davis, C B, and Curtis G M Blood Iodine Studies I The Quantitative Determination of the Iodine Content of Blood, J Lab & Clin Med 18 24 1932
Phillips, F J, and Curtis G M Blood Iodine Studies IV The Clinical Determination of Iodine in Blood, Urine and Feces Am J Clin Path 4 346 1934

by the more recent chromium trioxide oxidation method,¹² the average blood iodine did not quite reach the 5 per cent level of significance

From the total group of 28 patients with hypertension there were in all 16 given a diagnosis of essential hypertension without cardiac disease. Of the 16, only 5 had elevated blood iodine values, and these were accompanied by basal metabolic rates ranging from plus 5 to plus 19. The blood iodine was normal in the only 2 patients with malignant hypertension, despite accompanying basal metabolic rates as high as plus 24 to plus 32.

Of the 7 patients with hypertensive heart disease without decompensation, only 1 had an elevated blood iodine level, while 2 of 3 with hypertension and congestive failure had increased blood iodine values. On the other hand, in 7 patients with nonhypertensive heart disease, 5 of whom were rheumatic, there was no elevation of the blood iodine, not even in the 2 patients with congestive failure.

Hyperiodemia has been noted in essential hypertension by several investigators.¹³ Occasionally, blood iodine values as high as 100 micrograms per hundred cubic centimeters have been reported.^{13b} Such a notable increase is primarily suggestive of iodine medication¹⁴ rather than the presence of so severe a form of hyperthyroidism. Even proponents of the existence of hyperiodemia in hypertension expressed the belief^{13c} that this increased blood iodine, which accompanies but does not parallel^{13d} the elevated basal metabolic rate, indicates increased thyroid activity. Others reported normal¹³ and also low normal levels of iodine in the blood,^{13b} even in the face of basal metabolic rates as distinctly elevated as those in hyperthyroidism.^{13b} The traction of the

12 Matthews, N. L., Curtis, G. M., and Brode, W. R. Determination of Iodine in Biological Materials. Refinements of the Chromium Trioxide Oxidation Method, *Indust. & Engin. Chem.* **10**: 612, 1938.

13 (a) Veil, W. H., and Sturm, A. Beiträge zur Kenntnis des Jodstoffwechsels. *Deutsches Arch. f. klin. Med.* **147**: 166, 1925. (b) Paal, H. Elektrochemische Blutjodbestimmung, *Klin. Wchnschr.* **14**: 1394, 1935. (c) Burger, M., and Möbius, W. Der Jod und Cholesteringehalt des Blutes in seinen Beziehungen zur essentiellen Hypertonie, *ibid.* **13**: 1349, 1934. (d) Möbius, W., and Nolte, F. A. Verhalten von Grundumsatz und Blutjod bei Thyreotoxikosen, *Ztschr. f. klin. Med.* **128**: 174, 1935. (e) Vergleichende Blutjoduntersuchungen bei trockener und feuchter Veraschung. *Biochem. Ztschr.* **253**: 275, 1932. (f) Curtis, G. M., Cole, V. V., and Phillips, F. J. The Blood Iodine in Thyroid Disease. *Tr. Am. A. Study. Gorter*, 1934, p. 142. *West J. Surg.* **42**: 435, 1934. (g) Curtis, G. M. The Iodine Relationships of Thyroid Disease, *Surg. Gynec. & Obst.* **62**: 365, 1936.

14 Lohr, H. Beiträge zur Kenntnis des Jodstoffwechsels. I. Blutjodstudien unter physiologischen Verhältnissen, *Arch. f. exper. Path. u. Pharmacol.* **180**: 332, 1936.

15 (a) Lohr.¹⁴ (b) Turner, K. B., De Lamater, A., and Providence, W. D. Observations on the Blood Iodine. I. The Blood Iodine in Health in Thyroid and Cardioresenal Disease and in Leukemia, *J. Clin. Investigation* **19**: 515, 1940.

blood iodine insoluble in acetone or water appears to be a more reliable criterion than the whole blood iodine in the differentiation of hyperthyroidism from hypertension, since in clinically euthyroid hypertensive persons it is low normal to even subnormal¹⁶

Some have found the blood iodine increased in congestive heart failure^{13a} while others reported normal values in this disease.¹ Kisch found the range of blood iodine values in nonhypertensive heart disease of various sorts to be normal in patients with elevated as well as in patients with normal metabolism.¹⁷ Low blood iodine values, accompanying normal metabolism and serum cholesterol levels, have also been encountered in nonhypertensive heart disease, even when attended by congestive failure.^{1, b} Perhaps the occurrence of normal and low blood iodine in some patients with congestive failure may be explained in part by the therapeutic management of these conditions with digitalis, for on digitalization in the presence or absence of cardiac disease, hypertension or hyperthyroidism, a sharp drop in the blood iodine may ensue.^{13 c}

If renal function is sufficiently disturbed, a decreased urinary elimination of iodine with increased retention of iodine in the blood might be expected. An elevated blood iodine has been reported in renal failure.¹⁸ We have found the blood iodine increased in 1 patient with anuria, who, however, also had hypertension and arteriosclerosis. On the other hand, the blood iodine as well as the basal metabolic rate may be low in renal disease without renal failure, as reported in 3 patients with glomerular nephritis,^{1, b} or normal, as observed in 3 patients in our series (table 1), 2 with chronic glomerular nephritis and 1 with chronic pyelonephritis.

BLOOD DYSCRASIAS AND DEGENERATIVE DISEASE

We could find no significant increase in the average blood iodine in 9 patients with myelogenous leukemia, despite a greatly elevated basal metabolic rate^{1b} (table 1). Nevertheless, variation in the individual blood iodine values exceeded normal. A considerable elevation of the blood iodine accompanying an increased basal metabolic rate was encountered in 2 males with lymphatic leukemia (table 2). In one of these patients both the blood iodine and the basal metabolic rate declined to within normal limits two and one-half years following

16 Davison, R. A., Zollinger, R. W., and Curtis, G. M. The Fractionation of the Blood Iodine. I. Findings in Patients with Normal Thyroid Function and with Hypothyroidism, *J. Lab. & Clin. Med.* 27: 643, 1942.

17 Kisch, F. Ueber des Verhalten des Blutjodspiegels Kreislaufkranker. *Wien klin. Wchnschr.* 47: 1317, 1934.

18 Baldau, L. K., and Pincussen, L. Untersuchungen über den Jod und Bromgehalt des Blutes. *Klin. Wchnschr.* 9: 1505, 1930.

splenectomy. Increase in the average basal metabolic rate of 3 females with lymphatic leukemia was moderate and was not accompanied by any elevation of the blood iodine. The significant difference in the average blood iodine values of the males and females with lymphatic leukemia (table 2) may have been due to various factors, such as the therapeutic management of the disease, chronicity of its course, and the average age of the males and females. The lowest blood iodine in the 5 patients with lymphatic leukemia occurred in the only patient with the acute disease—an 11 year old girl whose basal metabolic rate, nevertheless, exceeded that of the other 2 females. The blood iodine in one male with an aleukemic lymphosarcoma was, as in the patient with acute leukemia, found to be normal (table 4). In 2 other cases of lymphosarcoma hyperiodemia has been observed.¹⁹

Elevation of the blood iodine in lymphatic leukemia often so definite has previously been reported.²⁰ On the other hand, a normal blood iodine has been found in myelogenous leukemia.²¹ K. B. Turner and his associates found the blood iodine elevated in 7 of 17 patients with lymphatic leukemia and abnormally low in 9 of 12 patients with myelogenous leukemia. The remainder had normal blood iodine values.^{1, b}

We observed no significant deviations in blood iodine in the other instances of blood disease under investigation, including 2 cases of Hodgkin's disease, in which an elevated level of iodine in the blood sometimes occurs,¹⁹ 2 of splenomegaly of undetermined origin, 2 of agranulocytosis and 3 of secondary anemia (table 1). The blood iodine was high normal in 1 patient with polycythemia vera (table 4) and in 1 with pernicious anemia (table 3). Veil and Sturm observed that in pernicious anemia the blood iodine may become greatly increased during the stage of remission and subsequently decrease to normal or even subnormal during an acute crisis.^{1, a}

The average blood iodine was normal in 12 patients with various types of nonmalignant tumors, in 6 patients with carcinomas and in 1 with osteosarcoma (tables 1 and 4). In none of these patients was there demonstrable involvement of either thyroid or liver. With the possible exception of the blood iodine in carcinoma of the liver,^{8b} the blood iodine has been generally found to be normal in cancer of nonthyroid tissues.²²

19 Turner, K. B., McAlpin, K. R., and DeLamater, A. Blood Iodine in Leukemia, *Proc. Soc. Exper. Biol. & Med.* **39**: 55, 1938.

20 (a) Veil and Sturm.^{13a} (b) Curtis.^{13c} (c) Turner, DeLamater and Province.^{15b} (d) Turner, McAlpin and DeLamater.¹⁹ (e) Curtis, G. M., Davis, C. B., and Phillips, F. J. Significance of the Iodine Content of Human Blood, *J. A. M. A.* **101**: 901 (Sept. 16) 1933.

21 Turner, DeLamater and Province.^{15b} Turner, McAlpin and DeLamater.¹⁹

22 Fowweather, F. S. The Iodine Content of the Blood of Patients Suffering from Cancer, *Brit. J. Exper. Path.* **11**: 400, 1930. (b) Kato, S. Blutjodspiegel bei einigen chirurgischen Erkrankungen mit besonderer Berücksichtigung der Kröpfe, *Tohoku J. Exper. Med.* **29**: 442, 1936.

In 1 patient with osteitis deformans the blood iodine, analyzed by the dry ash method,¹¹ was found to be considerably elevated (table 4), while in another patient with this disease, whose blood iodine was determined by the chromium trioxide method,¹² it was considerably

TABLE 3—The Blood Iodine in Single Instances of Nonthyroid Disease Determined by the Chromium Trioxide Method¹²

Clinical Diagnosis	Age	Sex	Blood Iodine Microgram ¹² /100 Cc	Basal Metabolic Rate	Duration of Symptoms
Above Normal + the 2 s d Limit *					
Rheumatic fever *	49	F	17.3	+10	3 wk
Eczema	10	F	8.5	+8	10 yr
Arteriosclerosis	69	F	8.3		
Spina bifida	49	F	8.1	-1	49 yr
Ringworm	34	M	7.5	-11	5 yr
Sebaceous cyst of neck	16	F	7.1	-8	10 yr
Dermatitis seborrheica	39	M	7.1	+12	
Between Normal and ± the 2 s d Limit *					
Prolapsed uterus	47	F	5.7	+27	11 yr
Pernicious anemia	76	M	5.3	-36	1 yr
Cystocele and retrocele	30	F	5.3	+7	4 mo
Underweight	10	F	5.2	-9	8 yr
Hyperparathyroidism	12	M	5.1	-70	10 yr
Subacute bacterial endocarditis	36	M	5.0		5 mo
Elephantiasis cruris	32	F	4.7	-4	11 yr
Myositis fibrosa	41	M	4.7		8 yr
Malnutrition	29	F	4.2	+18	3 mo
Radiculitis	23	F	4.2	+2	4 yr
Aortitis	45	F	4.1	+75	1 yr
Cystitis	30	F	4.1	-1	2 mo
Duodenal ulcer	32	M	4.1	+1	4 wk
Hypoparathyroidism	31	F	4.0	-11	6 mo
Undescended testis	21	M	4.0	± 0	11 yr
Chronic ulcer of leg	45	M	3.9		5 yr
Osteomyelitis	13	M	3.7	-21	6 mo
Intis	33	F	3.6	-7	
Thyroglossal cyst	45	M	3.4	-9	7 yr
Osteomalacia	27	M	3.3		7 1/2 yr
Influenza	59	M	3.3	-16	recent
Myasthenia gravis	34	F	3.1	+55	10 yr
Fibrous ankylosis of mandible	50	M	2.9		5 yr
Appendicitis	18	M	2.6		6 hr
Gastroenteritis	23	F	2.8		5 days
Brucellosis	53	M	2.5	+53	7 mo
Below Normal - the 2 s d Limit					
Osteitis deformans	59	F	1.7	+15	5 yr

* Two months after subtotal thyroidectomy for toxic nodular goiter
 † 2 s d Two times the standard deviation

reduced (table 3). The high blood iodine occurred in a man with symptoms of fifty years' duration, while the low value was noted in a female with symptoms of only five years' duration. In both patients the basal metabolic rate was elevated. These insufficient data on osteitis deformans indicate clearly the need for caution in basing deductions on

individual values alone. Such may not be representative of the whole group especially since there may be considerable variation of the blood

TABLE 4—*The Blood Iodine in Small Instances of Nonthyroid Disease Determined by the Dry Ash Method*¹²

Clinical Diagnosis	Age	Sex	Blood Iodine Microgram / 100 Cc	Basal Metabolic Rate	Duration of Symptom
Above Normal — the \pm d Limit *					
Cystic arachnoiditis †	0	M	~ 0		1 yr
Acute serofibrinous pleurisy	16	F	24.0		1 mo
Osteitis deformans	64	M	3.0	-21	30 yr
Chronic bronchitis	10	M	20.5	-12	5-6 mo
Between Normal \pm d Limit *					
Polycythemia vera	45	M	16		10 mo
Arterio sclerotic gangrene	60	M	1.5		2 wk
Hypopituitarism	14	M	16.0	-15	
Lymphosarcoma	32	M	14.5		1 mo
Internal hydrocephalus	51	F	14	-2	1 yr
Hypoovarianism	25	F	13.4	-10	4 yr
Osteosarcoma	15	M	13.5		3 mo
Elephantiasis cruris	44	F	13.0	-14	11 yr
Abnormal growth	11	F	12.5	-15	3 yr
Endocrine insufficiency	20	F	12.7	-11	4 yr
Ruptured meniscus	15	F	12.7		9 yr
Myasthenia	25	M	12.5	-4	25 yr
Ovarian degeneration microcytic	24	F	12	-27	4 yr
Idiopathic scoliosis	14	F	11.8		2 yr
Bronchopneumonia	1	M	11.7		2 wk
Cerebral concussion	45	M	11.2	-22	
Cerebral embolus	74	F	11.0		2 days
Glycosuria	18	M	11.0	-9	
Thromboangitis obliterans	57	M	9.7	-5	5 yr
Chronic tonsillitis	30	F	9.7	-3	
Osteomyelitis	30	M	9.5		3 $\frac{1}{2}$ yr
Harelip cleft palate	5	M	9.5		5 yr
Arteriosclerosis	65	F	9.3	-17	
Bladder stone	67	M	8.6	+5	1 yr
Sciatic neuralgia	59	M	8.0		7 mo
Deformity of sternum	19	M	8.0	-11	19 yr
Duodenal ulcer	55	M	7.5	-2	40 yr
Hypogonadism	15	M	7.5	-1	1 $\frac{1}{2}$ yr
Hypereosinophilism	44	M	7.5		6 yr
Solitary bone cyst	8	M	7.2	-7	6 yr
Neurodermatitis	60	F	6.9	-10	
Tuberculosis of breast	36	F	6.6	-4	2 yr
Bone dyscrasia	25	F	6.4	-15	2 mo

* \pm d. Two times the standard deviation

† Iodized poppyseed oil 40 per cent was injected in spinal canal a long time ago

iodine in any given disease, depending on associated pathologic conditions, particularly of the thyroid gland, and the type of medication previously employed, as well as various other factors

NONTHYROID ENDOCRINE DISTURBANCES

Our data on diabetes mellitus further illustrate the type of variation one might find in the blood iodine in any given disease. Two groups

of 3 patients each were investigated separately, because of a difference in the analytic technic employed for each case. In the more recent group the average blood iodine was normal (chromium trioxide method), whereas in a previous group (dry ash method) the average blood iodine was significantly reduced (tables 1 and 2). The average basal metabolic rates were normal in each group.

A lowered blood iodine in diabetes mellitus is consistent with the disputed²³ hypothesis of a *specific* antagonism between the thyroid and the pancreas²⁴. In keeping with this hypothesis the insulin treatment for hyperthyroidism has been attempted^{24b}. The rationale of this therapy obtains some biochemical support from the observation that administration of insulin may result in a decrease in the blood iodine^{1,2}. The inference might also follow that a low blood iodine occurring in a diabetic patient could be a result of insulin therapy.

High variability of the blood iodine in diabetes has been noted by R. G. Turner²⁵. In 13 "inpatients" and 54 "outpatients" with diabetes mellitus, over one third of the total 67 had subnormal blood iodine and almost another third had increased blood iodine values. This distribution of blood iodine levels in diabetes may parallel a similar distribution of the basal metabolic rates²⁶ in this disease.

The unfractionated blood iodine was normal in small groups with pituitary dwarfism, acromegaly, hirsutism, hypopituitarism, Addison's disease, "endocrine imbalance," mongolism and menstrual disturbances (table 1) and in single patients with other endocrine disorders, including hypoparathyroidism and hyperparathyroidism, hyperpituitarism, varying forms of hypogonadism and hyperinsulinism (tables 3 and 4). There were two exceptions. The blood iodine was elevated in 2 patients with Froehlich's syndrome (tables 1 and 2), despite a low but not significantly reduced average basal metabolic rate. It was increased in 1 patient with polyglandular dysfunction designated as "endocrine imbalance" (column "Dry Ash Method" in table 1).

Elevated blood iodine has been noted in the early stages of acromegaly²⁷. On the other hand, in 2 patients included in this study with

23 Shepardson, H. C., and Wever, G. K. Myxedema and Diabetes Mellitus with the Report of a Case, *Internat. Clin.* **4** 132, 1934.

24 (a) Veil and Sturm^{13a}. (b) Lawrence R. D. Four Cases of Exophthalmic Goiter Treated with Insulin, *Brit. M. J.* **2** 753, 1924.

25 Turner, R. G. Iodine Content of Certain Pathological Blood in a Goitrous Region, *Proc. Soc. Exper. Biol. & Med.* **29** 1294, 1932.

26 Boothby, W. M., and Sandiford, I. Summary of the Basal Metabolism Data on 8,614 Subjects with Especial Reference to the Normal Standards for the Estimation of the Basal Metabolic Rate, *J. Biol. Chem.* **54** 783, 1922.

27 (a) Perkin, H. J. Unpublished data. (b) Perkin H. J., and Laker, F. H. The Level of Iodine in the Blood, *Arch. Int. Med.* **65** 882 (May) 1940.

acromegaly present as long as eleven and nineteen years, the blood iodine was normal. Moreover, the acromegaly in 1 of these patients was accompanied by diabetes insipidus, a disease in which Blotner has observed an increased excretion of urinary iodine and a generally low normal blood iodine both of which conditions may be altered by the administration of posterior pituitary.²⁸

CERTAIN INFECTIOUS DISEASES

In most of the infectious diseases included in this series, we observed no significant elevation of the blood iodine. There were two exceptions. One was a group of 5 patients with syphilis (tables 1 and 2), among whom there was no record of iodine medication. However, 2 of the 5 patients also had hepatic damage (table 1) which may have contributed, at least in part, to the increased average blood iodine. Normal^{22b} as well as elevated¹⁸ iodine levels have been reported in syphilis.

A second group in which the average blood iodine was increased consisted of 6 males with various types of arthritis. Their blood iodine was found to differ significantly from that of 9 females with arthritis (tables 1 and 2). This difference in the average blood iodine of males and females could not be attributed to a difference in the average basal metabolic rate, which was normal in either group or to a difference in the average age of the patients or to the duration of symptoms. Other factors, however, may be involved, such as a difference in previous medication or in the relative preponderance of a certain type of arthritis in each group. The two highest blood iodine values were found in 2 of the 3 patients with arthritis due to *Neisseria gonorrhoeae* both males and 1 with accompanying syphilis. In both of these patients the elevated blood iodine diminished after fever therapy to normal levels.

The average blood iodine values of 11 patients with pulmonary tuberculosis (table 1), as is apparently also true of the urinary iodine in this disease,²⁹ was found to be normal. Similarly, the blood iodine was normal in 2 patients with tuberculosis of vertebra (table 1) in 1 with tuberculous cervical lymphadenitis and in 1 with tuberculosis of the breast (table 4). Nevertheless, an increase in the blood iodine has been reported in certain forms of tuberculosis^{22b}. Except for the blood iodine of 1 patient with chronic bronchitis and of 1 with acute serofibrinous pleurisy (table 4), the level was found to be normal in patients with other respiratory diseases, including sinusitis, bronchiectasis (table 1) and bronchopneumonia (table 4). The blood iodine was normal in one patient with chronic emphysema but elevated in another who had accompanying psoriasis.

²⁸ Blotner, H. The Amount of Iodine in the Blood and Urine in Patients with Diabetes Insipidus, *Am J M Sc.* **203** 708, 1942.

²⁹ Klassen, K. P., Curtis, G. M. and Hancock, R. A. The Urinary Iodine in Pulmonary Tuberculosis. *Am Rev Tuberc.* **42** 376 1940.

In a patient with cystic arachnoiditis, the high blood iodine noted (table 4) might be explained as a sequel to spinal injection of iodized poppyseed oil 40 per cent, although this had been performed "a long time ago." In a patient with rheumatic fever of three weeks' duration, the increased blood iodine (table 3) was more likely due to hyperthyroidism, even subsequent to a subtotal thyroidectomy two months previously for toxic nodular goiter, than to the presence of acute infection. In another patient with subacute bacterial endocarditis of five months' duration, the blood iodine was normal (table 3).

The occurrence of hyperiodemia in severe infections and in septicemia has been reported.³⁰ Kato found that while the blood iodine may be elevated in acute pyogenic infections and in spontaneous gangrene, it tends to be normal in chronic pyogenic infection.^{22b} On the other hand, in 5 cases of acute fever Veil and Sturm found a fall rather than a rise in the blood iodine level. They thought this might be due to an increase in the tissue requirement of iodine, as well as to an increase in the urinary excretion.^{13a} Fashena could find no elevation of the blood iodine level in various infectious diseases of children, including broncho pneumonia, mastoiditis, otitis media, pyelitis and cervical adenitis.³¹

CLUTANEOUS DISEASES

It has long been the clinical impression among dermatologists that iodides have a tendency to cause exacerbation of acne as well as produce acneform eruptions. Further support of this idea has not been adduced from studies on the blood iodine. Thus, Traub and Emmet reported a normal blood iodine level in 45 patients with acne vulgaris. Brill and Goyert could likewise find no increase in the blood iodine in 10 patients with eczema nor in 88 patients with various other dermatoses. The iodine in the skin was found to be increased to about four to five times normal in 2 patients with dermatitis herpetiformis. This was correlated with a slight increase in the blood iodine. However, 6 other patients with this same disease had elevation of the iodine level neither in the skin nor in the blood. On the basis of their investigations, Brill and Goyert concluded that there is no definite relation between the blood iodine and the dermatoses, which are often accompanied by a labile sympathetic nervous system.³²

30 Curtis, Cole and Phillips.^{13f} Curtis.^{13g} Curtis, Davis and Phillip.¹⁴ Kato.^{22b}

31 Fashena, G. J. A Study of the Blood Iodine in Childhood, *J. Clin. Investigation* 17 179, 1938.

32 Traub, E. F., and Emmet, R. Blood Iodine of Patients with Acne Vulgaris. *Arch. Dermat. & Syph.* 41 506 (March) 1940.

33 Brill, H., and Goyert, K. Blutjodanalysen bei Hautkrankheiten und ihre Beziehungen zum vegetativen Nervensystem, *Arch. f. Dermat. u. Syph.* 150 66 1940.

We have insufficient data to draw any conclusions with respect to the blood iodine in cutaneous diseases. However, it may be of some significance that in the few instances of a cutaneous disease under investigation (table 3) with the exception of that of neurodermatitis (table 4), the individual blood iodine values were elevated. These diseases, each represented by a single patient, are eczema, ringworm, sebaceous cyst of the neck and dermatitis seborrheica. The basal metabolic rates were within normal limits^{1b} ranging from minus 11 to plus 12 per cent. In 1 patient with empyema of six years' duration, with associated psoriasis the blood iodine was greatly elevated being almost twice as high as that in another patient with an uncomplicated empyema of two years' duration.

PSYCHIC AND NERVOUS DISTURBANCES

We noted no significant variations of the blood iodine in any of our patients with psychic or nervous disturbances. These included chiefly 19 patients with psychoneurosis, 9 with neurasthenia and 30 with "functional" disorders (table 1). In 3 patients with vagotonia (table 1), we found a low normal blood iodine which was accompanied in 2 of the 3 by low basal metabolic rates of minus 20 and 29 per cent. The latter was the average of three determinations made on three different occasions within a period of six months. During the six months the basal metabolic rate of this patient, as well as the blood iodine, steadily declined, the blood iodine to half its original normal value.

Veil and Sturm reported a lowered blood iodine in patients with vagotonia.^{12a} Perkin and Lahey maintained that the blood iodine levels in normal persons of a vagotonic type fall within the lower normal range, whereas they lie within the upper normal range in those of a sympathicotonic type.^{2-b} The blood iodine may be increased after stimulation of the nervous system or on the injection of epinephrine.^{12a} The subcutaneous injection of epinephrine apparently has no effect on the blood iodine of hyperthyroid patients, but will cause a rise in the "organic fraction" of normal persons.³⁴

Neustadt and Howard have observed that among the psychoses the blood iodine level deviates from the normal only among the *true* manic-depressive types, being high in the manic group (47 patients) and low in the depressive group (30 patients). There is a close parallelism between the level of the blood iodine and the manic-depressive changes in mood, but no parallelism between the blood iodine and change in motor excitement of these patients. On the other hand, the blood iodine is remarkably constant in patients with dementia paralytica, paranoia or schizophrenia,

34 Gutzert, K., and Parade, G. W. Blutjodstudien. XI. Die Beeinflussung der Blutjodverhältnisse durch Adrenalin, *Ztschr. f. klin. Med.* **135** 183 1938.

even despite changes in mood ³⁵ K. B. Turner and his associates could find no elevation of the blood iodine in 6 neurotic females ¹⁻⁶

SUMMARY

The iodine concentration in the whole blood of representative patients with 115 different nonthyroid diseases was determined. The findings are presented tabulated and discussed. A review of the pertinent literature is included.

It should be remembered that the groups studied were small and thus our results may not signify the general trend of the blood iodine levels in the disease, but rather types of variation which may occur. Moreover, it cannot be implied at this time that these variations are due to the disease itself rather than to other concomitant factors.

The average concentration of iodine in whole blood was found to be, with few exceptions, consistently normal in patients with nonthyroid diseases. Nevertheless, there are those instances in which certain pathologic processes may be associated with an increase of the blood iodine. These merit further investigation. They include, more so in this study, cholecystitis with cholelithiasis, and less frequently, essential hypertension and hypertensive cardiac disease. High elevations may sometimes occur in patients with lymphatic leukemia, and these are accompanied by increased basal metabolic rates. In some instances, for example in essential hypertension, a high level of iodine in the blood may perhaps be due to the type of medication or to an accompanying thyroid involvement.

Abnormal increase and even decrease in the blood iodine may also occur in patients with certain other nonthyroid diseases. These observations are especially difficult to evaluate owing to the scarcity of available data. Among such diseases are only a few of the many nonthyroid endocrine disturbances, certain infectious disorders and possibly, although questionably, certain diseases of the skin.

We found little evidence of any deviation from the normal or the average iodine level in whole blood in certain diseases of a psychic or neurogenic character. This was likewise true for myelogenous leukemia and for neoplasms, both benign and malignant, of neither thyroid nor hepatic origin.

In the nonthyroid diseases in which an elevation of the average level of iodine in the blood occurred, an increase in the basal metabolic rate was not always apparent.

³⁵ Neustadt R., and Howard L. G. Fluctuations of Blood Iodine in Cyclical Psychoses, *Am J Psychiat* 99:130, 1942.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

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CONGENITAL hypertrophic pyloric stenosis is the most common condition requiring surgical treatment in the infant. Although it was first described by Fabricius Hildanus in 1627, intelligent interest in the abnormality did not develop until 1887 when Hirschsprung gave a convincing description of the disease. The application of surgical measures to its correction dates back to 1892 when Cordua, of Hamburg, performed jejunostomy unsuccessfully. Subsequently various operative procedures were tried gastrojejunostomy being the operation most commonly employed. This carried a disturbing mortality of approximately 50 per cent. In 1907 Pierre Fredet performed what amounted to a Heineke-Mikulicz pyloroplasty in 2 cases. In 1911 Rammstedt when confronted with unusual difficulty in closing the muscle in that type of operation sutured the omentum over the protruding mucosa, with successful results. Thus, pyloromyotomy which is now employed, was evolved somewhat by accident and necessity.

Even though the operation is simple and almost foolproof the results are so gratifying, and at times spectacular that the surgeon usually takes great pride in its successful accomplishment. Although cases of this anomaly are now seen rather commonly I thought it might be of interest to this group of general surgeons to discuss the experiences of my colleagues and myself with a series of 129 infants on whom operation has been performed during the past twenty-four years.

My interest in this problem has been stimulated by Dr. R. R. Hippensteel, a pediatrician in Indianapolis, who concluded early in his practice that this was a surgical condition and gave up the long tedious course of medical management, then too often employed. He insisted then as now, that infants with this anomaly were best served by pyloromyotomy when the diagnosis was once established. A majority of the infants in this series were his private patients and because of my interest in this problem the series includes patients referred by a number of other pediatricians. Twenty of the patients were operated on in the charity hospitals, the other 109 were private patients. All these patients were cared for in cooperation with a pediatrician. The care of the infant is so different from the care of the average surgical patient

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association
Memphis, Tenn. Dec. 6, 1946

that I believe the pediatrician should play a prominent role in the care of all infants requiring surgical treatment. The problems of diagnosis, preoperative preparation and postoperative feeding of these babies were directed for the most part by pediatricians. The observations expressed here include the views of those associated with me in the care of these babies.

ETIOLOGIC FACTORS

Little is known of the cause of this condition, but it is generally agreed that the tumor develops before birth and that the onset of symptoms occurs when spasm and edema are superimposed on partial obstruction. It occurs predominantly in the male and in the first born. In the present series there were 109 males and 20 females, a ratio of 5.5:1. Approximately one-half the patients were first-born children.

	1 ST CHILD	2 ND CHILD	3 RD CHILD	4 TH CHILD
FAMILY 1	NORMAL ■	■	NORMAL ■	●
FAMILY 2	NORMAL ●	■ ■	(DR. MONTGOMERY'S CASE)	
FAMILY 3	■		(MATERNAL UNCLE'S GASTRO-JEJUNOSTOMY FOR STENOSIS)	
FAMILY 4	DEF. SYMPT NO SURGERY ●	■	NO OTHER CHILDREN	
FAMILY 5	■	■	NO OTHER CHILDREN	
FAMILY 6	■	■	NO OTHER CHILDREN	
FAMILY 7	■	■	NO OTHER CHILDREN	
FAMILY 8	■	■	NO OTHER CHILDREN	
FAMILY 9	■	●	NO OTHER CHILDREN	

Fig 1—Heredity as an etiologic factor in congenital pyloric stenosis as illustrated by its occurrence in more than 1 sibling—each of nine families. In this chart, affected boys are indicated by black squares, affected girls, by black circles, and twin boys by two black squares.

but since families of private patients are small it is difficult to state that this incidence is of much significance.

Heredity seems to be an important etiologic factor. In this series there were 6 instances of 2 affected members in one family. In 4 cases these were the first 2 boys of the family, in the fifth case the older patient was the first-born male child and the other was the second child, a girl. In the sixth case the older was the second child and the younger was the fourth child, a girl. One patient was the first-born male infant, whose mother's brother, a first-born child, had had a successful gastrojejunostomy for stenosis in Cincinnati in 1914.

Another male infant with stenosis had an older sister who had all the symptoms of a stenosis, with which she had lived without surgical intervention, although not too well. She had vomited a great deal until

she was $3\frac{1}{2}$ years of age and was a frail child. We felt that she undoubtedly had had a partial stenosis. Recently, I saw twins not identical, which were operated on by Dr. W. F. Montgomery on the same day for stenosis.

Cockayne and Penrose in London studied this problem in 212 cases and concluded that the underlying cause of congenital pyloric stenosis is the possession of a pair of abnormal genes, one received from each parent. They stated that should the recipient chance to be a boy and the first born he will almost certainly have this abnormality. A subsequent child or any daughter, even though she is the first born, is more likely to be normal than affected. They stated that the chances of the second child's being affected is not more than 1 in 20.

DIAGNOSIS

The symptoms usually mentioned are projectile vomiting, constipation, gastric contraction waves, loss of weight, dehydration and a palpable tumor. Of these, projectile vomiting and gastric contraction waves are, in our opinion, the most important. Although some authors have stated that they can feel the tumor in almost all cases, we felt it in less than 50 per cent of our patients and doubt whether it can be felt in a majority of babies when they are in a fair state of nutrition. Since the tumor can be felt in only a small proportion with any degree of certainty, we doubt the advisability of repeatedly disturbing the baby by the manipulations required to find it. Usually, about the second or third week the baby starts to spit up a small amount of its feedings and at a variable time later begins to have real projectile vomiting. Then in the epigastrium, especially after the feedings, strong gastric waves appear, passing from left to right. These often cause the infant pain and usually are followed shortly by vomiting. The baby is then placed on Sauer's thick cereal feedings¹ for at least forty-eight hours. Barbiturates may be used as a sedative, and atropine has been employed occasionally. If the infant continues to vomit the greater portion of its feeding and has the characteristic gastric contraction waves the diagnosis is established. A danger of the thick cereal feeding is that if there is still an obstruction the baby is dehydrated rapidly and becomes a poor risk if surgical intervention is delayed too long. Therefore, the child must be watched carefully. When we have been in doubt we have sometimes submitted the baby to a roentgenologic examination with a thin barium sulfate meal. It is our conclusion that this is not very helpful. On a few occasions the roentgenologist did not discover a stenosis when it was present, and on others he made a diagnosis of stenosis when the condition was pylorospasm. Moreover, it is diffi-

¹ The formula is as follows: Skimmed milk 9 ounces, water 12 ounces, farina or rice flour, 6 teaspoons, dextrimaltose 3 ounces.

cult to remove the barium sulfate from the stomach, even with lavage adding to the hazards of aspiration of this material when the baby vomits. Few babies now are given a barium sulfate meal.

The most difficult problem is to differentiate this condition from pylorospasm. In pylorospasm the vomiting is not so persistent and may be intermittent. The child does not become dehydrated or lose weight so rapidly and seems tenser. Yet I must confess that even with every diagnostic aid, including the roentgenogram, I have operated on a few babies, both in charity and in private hospitals, in whom no stenosis or other surgical pathologic condition was present. In several cases the roentgenologic diagnosis was conclusive, with almost complete retention of the barium sulfate after four hours. Although this fact is seldom reported, I am certain that every surgeon operating often for this anomaly will encounter about 1 case in 20 in which no stenosis is present. In such cases I have dilated the pylorus well and the babies have usually improved, although not so spectacularly as those with true stenosis. The average age of the infants with stenosis, at the time of operation, was between 5 and 6 weeks. The youngest baby was 13 days and the oldest 5 months of age.

SURGICAL PROCEDURE

The baby is prepared for operation by giving it subcutaneous injections of isotonic solution of sodium chloride, 10 cc per pound (45 Gm) of body weight every eight hours as indicated. These are usually given while the baby is under observation, when he is taking the thick cereal. When the baby is in a poor state of nutrition, he is given similar amount of blood in one or more transfusions. In recent years, the babies are in better condition and fewer need transfusions. If the baby has had a barium sulfate meal recently, the stomach is lavaged with a small tube before operation. I have employed general anesthesia in approximately 85 per cent of the babies but have used 0.5 per cent procaine hydrochloride by infiltration with babies who are considerably under par and are poor surgical risks. When local anesthesia is used 1 grain (0.065 Gm) of phenobarbital is given rectally one-half hour before operation as a sedative and a sugar teat is used to pacify the baby during operation. For general anesthesia, I almost always use ether but in 8 cases Dr F. A. Thomas, chief anesthetist at St. Vincent's Hospital, has given cyclopropane. He states that he has given almost 100 infants cyclopropane for various surgical procedures and is enthusiastic about its use. I much prefer ether but have permitted Dr. Thomas to use cyclopropane because of his skill and his enthusiasm for it. In these few cases it has proved to be a very satisfactory anesthetic.

The actual surgical procedure is simple but there are a few points which I consider important. The baby should be strapped on a special board and prepared as the anesthetic is started. The anesthetic is started

be as short as possible and only sufficient in amount to quiet the baby. A suction machine should always be in the hands of the anesthetist to prevent any aspiration of vomited material particularly when the patient

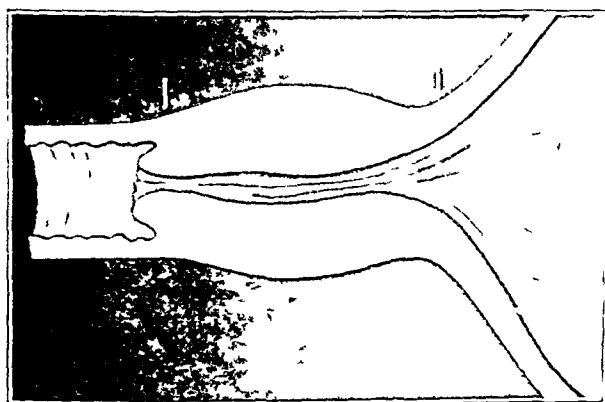


Fig 2—Longitudinal section of the stomach in a case of congenital pyloric stenosis showing the abrupt manner in which the tumor ends at the duodenum

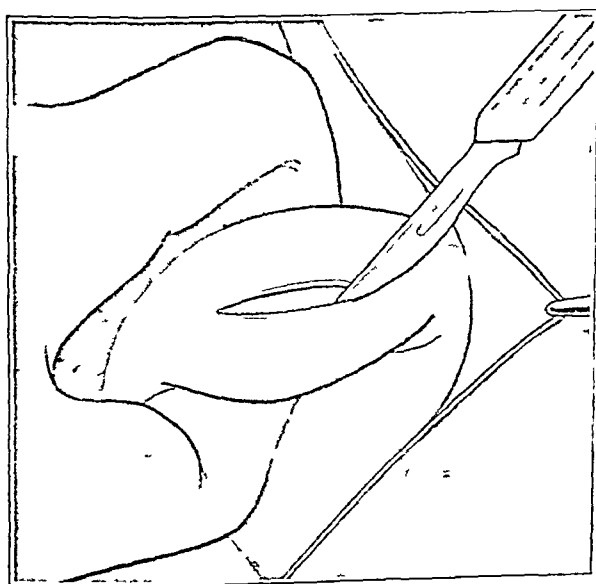


Fig 3—Division of superficial layers by sharp dissection

has had a barium meal. We almost lost a baby when this precaution had been overlooked. I have tried other types of incision, but I prefer a high short right rectus incision. The main requirement of the incision is that it be small. The average surgeon, who is accustomed to operating on adults, makes too large an incision. It need be only large

enough to permit one to introduce the finger and then deliver the tumor. An incision 1 to 1½ inches (2.5 to 3.7 cm) in length is usually sufficient. The tumor is delivered by gentle traction on the stomach and is held with the left hand. The tumor is incised on the anterior surface through approximately one-half its thickness and then is split by using the handle of the scalpel, especial care being taken at the duodenal end of the tumor. There have been reports of many instances in which the duodenum was opened at this point, a possibility which constitutes the main hazard of the procedure. Ladd and his associates² reported 14 such accidents among 763 cases, in all of which closure was made carefully, but there were 3 fatalities. Figure 2 illustrates the anatomic condition that makes it easy to enter the duodenum at

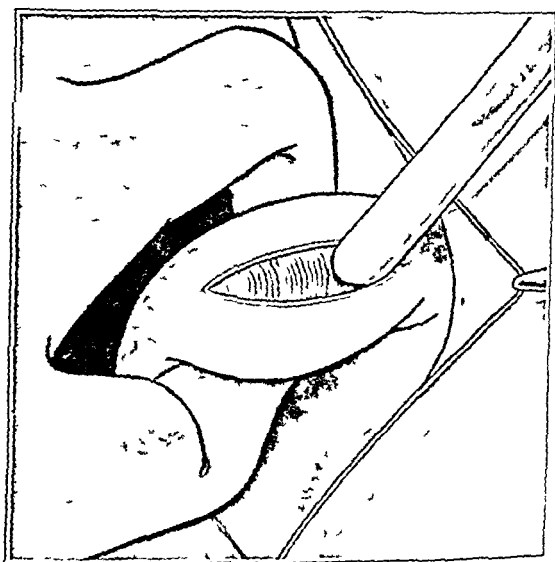


Fig. 4—Division of deep fibers with the handle of the scalpel

this point. I have practiced spreading the tumor widely and carrying the division well up onto the stomach, but leaving some of the transverse fibers at the lower end undivided over the point where the mucosa forms a pouch and is very thin. Thus, injury to the duodenum has been avoided, and the results have been entirely satisfactory. Bleeding usually requires no attention other than pressure for a moment. Occasionally a small vessel needs to be tied and this is best done by passing a fine suture or an atraumatic needle around it. The use of a hemostat to grasp the vessel is usually futile because the tissue is fragile and easily tears. The wound is closed in layers with fine chromic surgical

² Ladd W. E. and Gross R. E. *Abdominal Surgery of Infancy and Childhood*. Philadelphia W. B. Saunders Company, 1941.

gut and silk. A small gauze dressing, of sufficient size just to cover the wound, is strapped tightly with adhesive tape.

After operation it is important to see that the baby does not aspirate its vomitus before it recovers from the anesthesia. Feeding is begun two hours after operation. Various formulas have been used, all employing the principle of starting the feedings early and giving small amounts frequently. One-half ounce (14 cc) of a diluted milk formula is given every two hours for the first twenty-four hours with one-half ounce of plain water or 5 per cent solution of beta lactose on the alternate hours. After twenty-four hours the amount of each is increased as tolerated.

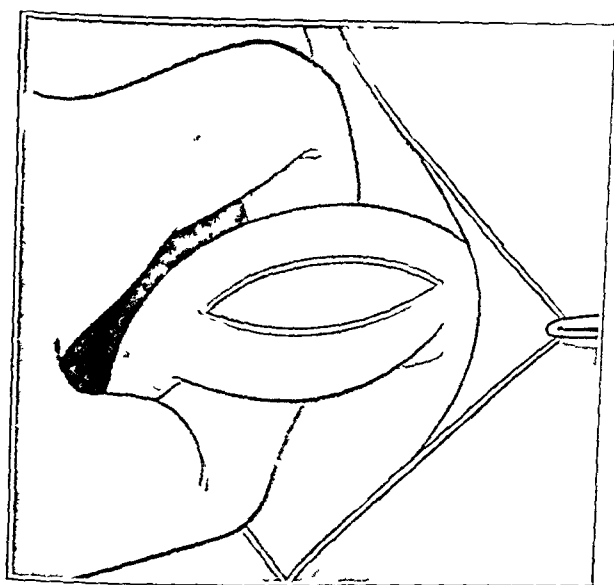


Fig 5—A few fibers at the duodenal end not divided but with separation carried well onto the stomach.

The baby is given a small dose of barbiturate if it is restless and subcutaneous injections of isotonic solution of sodium chloride if it seems dry. However, we feel that these babies should not be overtreated and that they do better if they are allowed to recuperate with the minimum amount of subcutaneously administered fluids. The average stay of the baby in the hospital after operation is six to seven days.

I have had no case of wound separation or evisceration. Approximately 10 per cent of the wounds have had drainage, varying from a small amount of serum, in most cases, to moderate infection, in a few cases. I believe this is because the wound in the undernourished infant does not heal so well as in the adult. No serious complications have resulted from the drainage.

I have operated on 129 babies, with 2 deaths. One death was that of a premature child weighing 3 pounds (1,360 Gm) at birth, the infant was in an incubator for more than one month, and at three months it weighed 4 pounds (1,814 Gm), when the diagnosis of a stenosis was made. It survived operation and was doing nicely until an obstruction of the small bowel developed on the tenth postoperative day, causing the infant's death. The second death was that of a baby who did well after operation and was taken to its home in a neighboring city. It was brought back six weeks later in a terrible state of malnutrition with recurrence of its stenosis. It was prepared with blood transfusions and subcutaneous administration of fluids and was reoperated on. A small, threadlike, firm band, 1 mm in diameter, was observed at the pylorus, completely closing the lumen. This was divided, but the child did not survive. It has been unnecessary to reoperate on any of the other infants, but in this series were 2 babies who had been operated on elsewhere, two weeks and one month respectively, before and the tumor had been insufficiently divided or the fibers had reunited. In each case the infant recovered after more complete division of the tumor. I believe that when a secondary operation is necessary it is because there was incomplete division of the tumor, and not because the fibers have reunited. In my case, I feel certain that a few strands of the transverse fibers were overlooked and not divided and that these fibers hypertrophied and caused the subsequent recurrence. Since that time I have carefully divided all such fibers.

Various observers state that this hypertrophied tissue disappears in a relatively short time after it has been divided. One of the babies who had completely recovered from the stenosis died three months later, of an unrelated acute infection. Postmortem examination revealed that the pylorus was normal, with a small tab of omentum adherent to the scar. In the baby operated on again after six weeks there was no evidence of disappearance of the tumor, although it had been well divided except for the small band. I did an appendectomy on another child eight years after the operation for stenosis and observed that the pylorus was normal.

END RESULTS

There were 2 deaths among the 129 infants in this series. The other babies have done remarkably well. Some regurgitated a small amount of their feedings for a short time, but I know of no other simple surgical procedure that has produced such immediate relief of symptoms and such permanently satisfactory end results as pyloromyotomy for stenosis in infancy. I doubt the advisability of treating medically any infant with stenosis when surgical relief is so simple and satisfactory. The infants for whom medical management has been tried and who have required operation at the age of 3 months or more have often been poor surgical risks.

SUMMARY

Pyloromyotomy for stenosis in infancy is a simple operation that should carry a very low mortality if not delayed too long and if the baby is properly prepared. The end results are extremely gratifying. I have operated on 129 infants, with 2 deaths, 1 of which could have been avoided. Of these infants 109 were males and 20 females. Approximately one-half were the first born of the family.

That heredity is an important etiologic factor is indicated by the frequency with which more than 1 case has occurred in the same family.

The diagnosis can be established by observing projectile vomiting and strong gastric contraction waves following the use of thick cereal feedings over a short period. It is doubtful whether roentgenologic examination is of much value, and a barium sulfate meal should be avoided except when there is an unusual problem in diagnosis.

I have been unsuccessful in feeling the tumor in the majority of cases and doubt whether its palpation is necessary to establish the diagnosis.

Babies with this defect are small and should be handled gently. Light ether anesthesia is the most satisfactory form in the majority of cases.

The abdominal incision should be small. Special care should be taken at the duodenal end of the tumor to avoid injury to the mucosa by leaving a few transverse fibers with the incision carried well onto the stomach.

The diagnosis and major portion of the preoperative and postoperative management should be entrusted to a competent pediatrician.

A group of pediatricians, particularly Dr. R. R. Hippensteel, referred the majority of these babies to me and directed the major portion of their care.

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DISCUSSION

Dr. JOHN E. OWEN, Indianapolis: Dr. Nafe has completely covered the subject of congenital hypertrophic pyloric stenosis and has given us his experience with this clinical entity so that any discussion can be only a summarization of his points and a consideration of minor technical points. The surgeon who has a well qualified pediatrician to make the diagnosis, prepare the patient for surgery and arrange for postoperative management need be concerned only with the surgical technique.

In Indianapolis my colleagues and I feel that this portion of the problem is well under control. Our problem is to perfect our professional measure. The most important technical points are as follows:

1. Proper restraint of the patient is essential. The use of a well padded splint and light weight towels assure the surgeon a stationary field for operation.

2. Use of local anesthesia supplemented with a sugar teat will avoid the complication of aspiration and in our hands has been adequate.

3. A high right rectus incision, splitting the transversus fibers, will prevent postoperative evisceration, especially if placed high enough to require retraction of the liver. Such an incision will also avoid being too large, a criticism which Dr. Nafe has made. It will admit one finger only.

4 Fine curved intestinal needles should be used as tractors to pick up the stomach and deliver the tumor. Handling with forceps should be avoided as it will delay the return to normal peristaltic activity.

5 After the tumor has been split, the parts must be spread apart, so that submucosa bulges well into the defect. Several recurrences, requiring a second operation, have seemed to arise from failure to do this.

6 A fine silk suture is used to control any bleeding from the transploric vessels. Failure to recognize the possible seriousness of such bleeding resulted in our only fatality. Compression on the surface of the tumor with forceps is unreliable and a suture ligature is safe.

7 Recognition of the danger of trauma to the duodenum is important. The best measure to prevent such trauma is care in not extending the serosal incision over the duodenal margin. If injury does occur, closure of the defect with an omental patch sutured in place will suffice to control the situation.

8 Passage of a catheter through the esophagus into the stomach will deflate this viscus and permit of easy return to the abdomen.

9 Careful closure with fine suture material completes our technic. Dr Nafe's skill, as demonstrated by his report, can well be envied. The points I have enumerated helped us to maintain satisfactory results and to reduce our complications.

DR GEORGE B. PACKARD JR., Denver. The operation for congenital pyloric stenosis, while it was simplified to a great extent by the Rammstedt procedure, still carried a rather high mortality rate for a number of years. This mortality was the result of two factors. First, all babies with this defect were kept as medical patients and were referred to the surgeon only as the last resort, so that he had to deal with a starved and dehydrated infant. Second, when the surgeon received such a patient, he considered that the starving infant needed emergency treatment and operated immediately, without proper restoration of the fluid and electrolyte balance.

Like Dr Nafe, we have found no disadvantage in a high right rectus incision after the patients have vomited only one or two weeks, and it is our practice, as it is his, to see that they receive sufficient fluids and electrolytes parenterally. It is our custom to give practically all these patients either plasma or blood intravenously, before or during or after operation.

One or two points may be mentioned. We do not feed these babies for forty-eight hours after the surgical procedure. We feel that they should be treated like any other patient whose stomach has been handled, the stomach is not ready for food and sufficient nourishment can be given intravenously. We do not feed them. My personal series of cases is now about 140, and in the last 88 cases there has been no fatality.

Occasionally one of these patients shows bleeding from the stomach before or after operation, even though the stomach has not been opened. It is this for a while that this might be due to a vitamin K deficiency, but this problem at this time was determined in a number of consecutive cases and we were not able to find any increase.

I should like to mention 1 case that of a boy aged 7½ years who came to the Children's Hospital with a history of having had a typical Rammstedt operation eighteen days before for congenital pyloric stenosis. The physician stated that the baby had done very well for a week and then had begun to vomit and show typical signs of obstruction and had lost all he had gained.

It was planned at operation to expose the pylorus again and to make an incision or divide whatever fibers had not been sectioned by the Rammstedt

pylorus could not be exposed. It was involved in adhesions and inflammatory tissue, so a posterior gastroenterostomy was performed. This operation had at first been the standard procedure for this abnormality but it was followed by a prohibitive mortality. The child made as good a recovery as that which follows the ordinary Rammstedt procedure, we felt therefore that a properly prepared infant could stand a gastroenterostomy as well as a Rammstedt pyloroplasty.

Like Dr Nafe, we have found no disadvantage in a high right rectus incision with splitting. In making the closure we do not suture the fascia as a separate layer or bury any material. We employ a fine surgical gut for the peritoneum and use either two or three silk figure 8s which include the skin and fascia and in that way we have no foreign material except in the peritoneum. The incisions seem to heal more kindly. I congratulate Dr Nafe on his fine results and his excellent presentation.

DR JOHN J IRELAND Chicago. At the Children's Hospital in Chicago in the last ten years my colleagues and I have performed operation for pyloric stenosis on 260 patients. There have been 2 deaths in this series a mortality of 0.7 per cent. Of the 2 deaths 1 occurred about twelve hours and the other about fourteen hours after the operation. On 1 patient autopsy was performed revealing a tremendous dilatation of the right side of the heart on the other no autopsy was held, so the cause of death was not known.

Among the last 109 patients—in other words all those operated on since 1943—there were no deaths. I should like to ask the speaker what method of closure he would use if he accidentally perforated the duodenum.

Doty, in 1944, reported a method in which if he perforated the duodenum or opened the duodenum he closed the primary incision immediately and then turned to a new place in the tumor and made a new incision and carried out the same type of operation again.

In our hospital, emergency operations are not performed on infants with this defect. The patients are kept long enough to be hydrated before the operation is done, and some of them are given blood transfusions. In every case in the last ten years, I think that a tumor has been felt before the operation.

DR CLEON A NAFF, Indianapolis. I wish to thank the discussants for their contributions to this subject. One of my anesthesiologists has often remarked at the close of this operation, "You aren't going to charge for that little job, are you?" In other words, the procedure is not an extensive one.

The last discussant asked what I should do if I accidentally opened the duodenum. I had always thought that the proper procedure would be to suture a portion of the omentum to the opening at the same time closing it with a very fine suture. That was the procedure first used by Dr Rammstedt when he devised the operation now employed so widely.

I appreciate the fact that my end results have been good because our pediatricians are convinced that babies with this defect should be operated on early. They have prepared the infants well, and as a result the mortality has been especially low. There should be no mortality in these cases except in that occasional case of neglect through the family's failure to see a good pediatrician or refusal to permit operation.

As I previously stated I have no objection to the use of blood transfusions. I use them in cases of serious neglect. I do feel that traumatizing the baby in trying to get into the veins retards recovery unnecessarily, especially when the infant is in fairly good condition. I allow the baby to get well as rapidly as possible on his own power when the condition has been corrected surgically by giving him the minimum amount of artificial injections indicated and I find that the powers of recovery of these infants are usually remarkable.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

XIII NEUROMUSCULAR DISORDERS EXCLUSIVE OF POLIOMYELITIS

Prepared by
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DURING 1945 there has been still greater increase in the amount of literature dealing with neuromuscular disorders, especially cerebral palsy. Literature in the field of neuromuscular disorder exclusive of poliomyelitis is apparently coming to deal more and more with study in distinguishing between the pyramidal and the extra pyramidal tracts. The material can be considered under the following headings: (1) cerebral palsy, (2) paralysis of other types, (3) muscle disorder, (4) muscular atrophy, dystrophy and myotonia, and (5) traumatic conditions of the nerves.

A paper by Kennard and Welch³⁸⁶ of an experimental nature utilizing monkeys and chimpanzees, is of great importance with regard to distinguishing between different types of damage to the cortex and in differentiation between areas 4 and 6. Removal of area 6 is followed by spastic paresis while removal of area 4 is followed by paresis without spasticity. Removal of the postcentral gyrus caused transient flaccidity. Also, the removal of areas 4 and 6 together resulted in immediate spastic paresis. This is of importance in distinguishing upper motor neuron flaccidity, which has been known to exist in spastic paralysis for years, and lower motor neuron flaccidity.

A paper by Lassek³⁸⁷ discusses the relationship of the Babinski sign to the pyramidal syndrome and shows that the sign is not necessarily consistent in all these patients. Victor Gonda³⁸⁸ discusses signs of pathologic changes in the pyramidal tract and describes their use. He includes among these the Babinski sign and the various modified techniques such as the techniques of Chaddock, Oppenheim and Gordon. The Rossolimo sign and the Hoffmann sign are also described. Other

386 Kennard, M. A., and Welch, W. K. Relation of Cerebral Cortex to Spasticity and Flaccidity, *Tr. Am. Neurol. A.* **70**: 158-164, 1944.

387 Lassek, A. M. Human Pyramidal Tract: Correlation of Pathologic Signs and Pyramidal Syndrome. *Arch. Neurol. & Psychiat.* **53**: 375-377 (May) 1945.

388 Gonda, V. E. Pathologic Pyramidal Tract Signs: Their Interpretation and Evaluation. *M. Clin. North America* **29**: 45-61 (Jan.) 1944.

mentioned which are of value in showing disturbances of the pyramidal tract

Lubin³⁸⁹ contributes a discussion of the pyramidal tract as regards anatomy, histology, relationship and function. Thorne³⁹⁰ also discusses the pyramidal tract, from the point of view of developmental studies and types of associated diseases.

Rutherford discusses the cause of extraneous movements in spastic paralysis³⁹¹ and also makes a comparative study of the speech in children with cerebral palsy³⁹². He evaluates the speech on the basis of loudness, pitch, rate, rhythm and quality.

Odoroff³⁹³ discusses the occupational background of cerebral palsy in the parents of children with cerebral palsy.

Pick and Unna³⁹⁴ describe effects of experiments with curare and curare-like substances in the central nervous system. They conclude that crystalline d-tubocurarine chloride dihydro-beta-erythroidine hydrochloride, quinine ethochloride, nicotine and thiamine inhibited and suppressed the electrical activity of the frog brain. Neostigmine failed to influence the effect of these substances on brain potentials. They conclude that the mechanism is an inhibition of central synaptic transmission.

Lieutenant Commander Harvey E. Billig Jr.³⁹⁵ discusses reinnervation of muscles by neurotrippsy. In the open surgical method this is carried out by compressing the nerve branches with a small hemostat sufficiently to interrupt the enclosed axons, without disrupting the sheath. In the closed method, a blunt instrument is kneaded through the muscle vigorously, deeply and repeatedly throughout its entire area. Attempt is made to spread the muscle apart in as many places as possible. The factors necessary to be considered in analysis of nerve-muscle function are described, and it is important that reeducation of muscles for further function should be carried out.

389 Lubin, A. J. Relationship and Function of Pyramidal Tract. *Am J M Sc* **209** 111-127 (Jan.) 1945

390 Thorne, F. C. Developmental Studies of Pyramidal Spasticity. *Am J Ment. Deficiency* **49** 43-52 (July) 1944

391 Rutherford, B. R. Extraneous Movements in Cerebral Palsy. *Physiotherapy Rev* **25** 63-67 (March-April) 1945

392 Rutherford, B. R. Comparative Study of Loudness, Pitch, Rate, Rhythm and Quality of Speech of Children Handicapped by Cerebral Palsy. *J Speech Disorders* **9** 263-271 (Sept.) 1944

393 Odoroff, M. E. Occupational Background of Cerebral Palsy. *Am J Ment. Deficiency* **49** 369-372 (Jan.) 1945

394 Pick, E. P., and Unna, K. Effect of Curare and Curare-Like Substances on Central Nervous System, *J Pharmacol & Exper Therap* **83** 59-70 (Jan.) 1945

395 Billig, H. E., Jr. Muscle Reinnervation. *J Internat Coll Surgeon.* **7** 457-461 (Nov.-Dec.) 1944

Two papers, one by Holmes, Highet and Seddon³⁹⁶ and the other by Parkes,³⁹⁷ contribute to the already extensive literature regarding ischemic contracture with special reference to Volkmann's contracture

Chandler³⁹⁸ discusses isolated paralysis of serratus anterior muscle from the point of view of cause and treatment, with 4 reports of cases Badolle³⁹⁹ also describes isolated paralysis of the serratus magnus

Rosen⁴⁰⁰ discusses abnormalities of the brachial plexus of traumatic origin in paratroopers, and Toft⁴⁰¹ discusses brachial paralysis in general, with special reference to obstetric paralysis of the upper extremities

Peacher and Robertson⁴⁰² discuss the causes of, and neurologic complications in, paralysis following the use of typhoid vaccine

Burdick, Whipple and Freeman⁴⁰³ discuss amyotonia congenita (Oppenheim's disease) with reports of cases, histologic studies and description of the exact physical findings to be expected They conclude that it is thought to originate from a developmental defect of the Betz cells in the motor cortex and the anterior horn cells of the spinal cord

Cerebral Palsy—In the field of cerebral palsy it is obvious that there are many complications requiring treatment besides complications affecting the locomotor system alone

McKibben⁴⁰⁴ points out the various complications in speech which require consideration Her article is based on her own experience as a child She discusses the effect of environment on the ability of a person with cerebral palsy to speak There are many different speech disturbances she considers

396 Holmes, W, Highet, W B, and Seddon, H J Ischemic Nerve Lesions Occurring in Volkmann's Contracture, *Brit J Surg* **32** 259-275 (Oct) 1944

397 Parkes, A R Traumatic Ischemia of Peripheral Nerves, with Some Observations on Volkmann's Ischaemic Contracture, *Brit J Surg* **32** 403-414 (Jan) 1945

398 Chandler, F A Isolated Paralysis of Serratus Anterior Muscle, *S Clin North America* **25** 21-27 (Feb) 1945

399 Badolle, R Paralyse du nerf du grand dentele, *Lyon chir* **37** 1-6-18 1941-1942

400 Rosen, V H Traumatic Neuropathy of Brachial Plexus in Paratroopers *Bull U S Army M Dept*, January 1945, no 84, pp 121-122

401 Toft G On Obstetric Paralysis of Upper Extremities (Erb Duchenne and Klumpke's Brachial Plexus Paralysis), *Acta orthop Scandinav* **13** 218-270, 1942

402 Peacher, W G, and Robertson R C L Neurological Complications Following Use of Typhoid Vaccine, *J Nerv & Ment Dis* **101** 515-526 (June) 1945

403 Burdick, W F, Whipple D V, and Freeman, W Amyotonia Congenita (Oppenheim) Report of Five Cases with Necropsy, Discussion of Relationship Between Amyotonia Congenita, Werdnig-Hoffman Disease, Neonatal Poliomyelitis and Muscular Dystrophy *Am J Dis Child* **69** 295-307 (May) 1945

404 McKibben, S Spastics Speech Situation, *Quart J Speech* **31** 3 3-362 (Oct) 1945

Rutherford ⁴⁰⁵ discusses hearing loss in palsied children as measured by the audiometer. He points out that there is a greater percentage of hearing loss in the patients with extrapyramidal disorders.

Berger ⁴¹¹ in an enlightening paper entitled 'Subjective Observations on Cerebral Palsy,' discusses many phases of the condition from his own experiences.

Palmer and Zerbe ⁴⁰⁷ have an interesting paper on the control of athetoid tremors and sound stimuli of different types. This is an extensive paper and of considerable value.

Wagley ⁴⁰⁶ discusses the characteristics of spasticity unassociated with paralysis in experiments on the *Macaca mulatta*. He points out that there is an intimate functional and anatomic relationship between the corticofugal systems from area 4s and the reticulospinal tracts. This paper is of great interest in connection with the origin of spasticity in the cortex.

Norfleet ⁴⁰⁹ has prepared a general article for technicians which enumerates various reflexes, including tendon reflexes, sucking reflexes, abdominal reflexes and cremasteric reflexes. The pyramidal and extrapyramidal systems are discussed briefly, as are the cause of cerebral palsy and its treatment by education.

In another article Norfleet ⁴¹⁰ discussed the psychologic background for the education of children with cerebral palsy.

Jennings ⁴¹¹ has written an article designed to acquaint the general public with some of the fundamental problems of cerebral palsy. It describes the therapeutic day nursery at the Michael Reese Hospital in Chicago in some detail.

O'Brien ⁴¹² describes the types of disorders of patients under treatment and study at the Department for the Correction of Motor Disabilities of the Neurological Institute in New York. There is one group of 18 who have five treatments a week and special educational facilities. The second group, of about 100, come in for treatment

⁴⁰⁵ Rutherford, B. R. Hearing Loss in Cerebral Palsied Children. *J. Speech Disorders* **10** 237-240 (Sept.) 1945.

⁴⁰⁶ Berger, C. C. Subjective Observations on Cerebral Palsy, *J. Speech Disorders* **10** 297-302 (Dec.) 1945.

⁴⁰⁷ Palmer, M. F., and Zerbe, L. E. Control of Athetotic Tremors by Sound Stimuli, *J. Speech Disorders* **10** 303-319 (Dec.) 1945.

⁴⁰⁸ Wagley, P. F. Study of Spasticity and Paralysis, *Bull. Johns Hopkins Hosp.* **77** 218-273 (Sept.) 1945.

⁴⁰⁹ Norfleet, G. M. Cerebral Palsy and Reflex Action. *Physiotherapy Rev.* **25** 114-117 (May-June) 1945.

⁴¹⁰ Norfleet, G. M. Habits and Skills Among Cerebral Palsy Children. *Physiotherapy Rev.* **25** 155-159 (July-Aug.) 1945.

⁴¹¹ Jennings, D. C. What Can Be Done for Spastic Child? *Hypertension* **23** 834 (Nov.) 1945.

⁴¹² O'Brien, V. Treatment of Children with Cerebral Palsy. *New York State J. Med.* **45** 1548-1550 (July 15) 1945.

once or twice weekly. The types are classified as (1) spasticity, (2) involuntary motions, mostly athetosis, and (3) incoordination or ataxia, treatment of each type is described. She discusses the complications such as mental retardation and hearing defects, and also discusses the causation.

Paralysis of Other Types—Durman⁴¹³ discusses an operation for paralysis of the serratus anterior, recognizing that this is a rare condition. The operation described differs definitely from the Tubby operation and those described by Ober and Dickson.

Yaskin⁴¹⁴ deals with painful conditions of the upper extremities and shoulder girdle and discusses the differential diagnosis of neuritis, bursitis and coronary diseases in detail.

Muscle Disorders—Simon and Senturia⁴¹⁵ present a report of a case of intermuscular lipoma of the thigh of definite traumatic origin.

Simon⁴¹⁶ reports 6 additional cases of muscle hernia in the arm and leg and the surgical treatment thereof, and in another paper Simon and Sacchet⁴¹⁷ review the literature and report 12 additional cases of muscle hernia in the leg.

Herz⁴¹⁸ discusses herniation of subfascial fat in relationship to pain in the lower part of the back, with a report of 85 cases.

Muscular Atrophy, Dystrophy and Syringomyelia—Kay and Gaskill⁴¹⁹ describe an unusual heredofamilial neurologic disease which fits fairly well in the category of the Charcot-Marie-Tooth type of progressive muscular atrophy but with a strong hereditary picture involving many members of the family for several generations.

Donald⁴²⁰ presents 3 cases of dystrophia myotonica in which the difficulty in relaxation is diminished by quinine and to some extent by epinephrine and calcium but which is increased by neostigmine, however,

413 Durman, D. C. Operation for Paralysis of Serratus Anterior, *J Bone & Joint Surg* **27** 380-382 (July) 1945.

414 Yaskin, J. C. Painful Affections of Upper Extremity and Shoulder Girdle. Neurologic Considerations, *Clinics* **4** 275-293 (Aug.) 1945.

415 Simon, H. E., and Senturia, H. R. Intermuscular Lipoma of the Thigh with Roentgenologic Findings, *South M J* **39** 624-626 (Aug.) 1946.

416 Simon, H. E. Muscle Hernia, with Report of Six Additional Cases in Arm and Leg, *Mil Surgeon* **97** 369-374 (Nov.) 1945.

417 Simon, H. E., and Sacchet, H. A. Muscle Hernias of the Leg, *Am J Surg* **67** 87-97 (Jan.) 1945.

418 Herz, R. Herniation of Subfascial Fat as a Cause of Low Back Pain. Results of Surgical Treatment in Thirty-One Cases, *J Internat Coll Surgeons* **9** 339-346 (May-June) 1946.

419 Kay, C. F., and Gaskill, H. S. Heredofamilial Neurologic Disease Resembling Charcot-Marie-Tooth Type or Progressive Atrophy, in *Chirac Famil.*, *Am J M Sc* **210** 342-346 (Sept.) 1945.

420 Donald, R. A. Dystrophia Myotonica. *U S Nav M Bull* **45** 733-735 (Oct.) 1945.

quinine while providing symptomatic relief, did not alter the course of the disease

Evans and Love⁴²¹ discuss familial progressive dystrophy in three separate generations

Pendergrass, Gammon and Powell⁴²² clearly show the changes in bone which may be associated with syringomyelia following severe trauma or minor injuries. They show the necessity for careful roentgen studies in such instances

Traumatic Conditions of the Nerves—Holmes, Hignet and Seddon⁴²³ discuss the ischemic nerve lesions occurring in Volkmann's contracture in a carefully worked up and extensive paper. They cover tests, causes, histologic observations and the present status of treatment

Spiegel and Lewin⁴²⁴ present 3 cases of tourniquet paralysis and discuss the various types of tourniquets and their effects

Milch⁴²⁵ discusses peroneal paralysis secondary to angulation of tibial fractures

XIV FRACTURES

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FRACTURES OF THE UPPER EXTREMITY

Fractures of the Humerus—Godfrey⁴²⁵ in a study of gunshot wounds of the humerus associated with fracture arrives at the following conclusions: 1. Gunshot wounds of the humerus present the problem of a fracture difficult to immobilize, plus a wound, often extensive, requiring management. 2. In order effectively to immobilize the frac-

421 Evans, W. A., and Love, C. H. Familial Progressive Dystrophy in Three Generations Living in Same Neighborhood, Mississippi Doctor **23** 369-372 (July) 1945

422 Pendergrass, E. P., Gammon, G. D., and Powell, J. H. Rapid Development of Bone Changes in Patient with Syringomyelia as Observed Roentgenologically, Radiology **45** 138-46 (Aug.) 1945

423 Spiegel, L. J., and Lewin, P. Tourniquet Paralysis: Analysis of Three Cases of Surgically Proved Peripheral Nerve Damage Following Use of Rubber Tourniquet, J. A. M. A. **129** 432-435 (Oct. 6) 1945

424 Milch, H. Anterior Transposition of Peroneal Nerve for Traction Paralysis, J. Bone & Joint Surg. **27** 608-614 (Oct.) 1945

425 Godfrey, G. Treatment of Compound Fractures of the Humerus. Australian & New Zealand J. Surg. **14** 114-118 (Oct.) 1944

ture a shoulder spica cast must be used [ED NOTE (L D B) Because of the wide range of motion in the shoulder girdle a shoulder spica does not effectively immobilize the shoulder or upper fragment of a fractured humerus] 3 Uninterrupted fixation combined with accessibility to the wound for the purpose of doing a proper dressing is essential. A prefabricated cast which is designed to accomplish these objectives is described

The value of the hanging cast method of treatment for compound fractures of the humerus is discussed by Macey and Coventry.⁴²⁶ In most instances the compound wounds were healed on removal of the casts. None of their patients showed extensive osteomyelitis. The technic of application of the cast is described.

[ED NOTE (L D B) —Others have had the same satisfactory experience in the use of the hanging cast in treating compound fracture of the humerus.]

Fitts, Kirby and Bray⁴²⁷ found that 3 per cent of all battle casualties during the North Burma campaign of 1943-1944 were complete gunshot fractures of the humerus. Sixty of 100 patients admitted for this lesion were followed long enough to determine the end result. In their hands debridement from one to several days after injury was of value in preventing or limiting infection and in shortening the period of wound healing. On the basis of their observations the authors arrived at the following conclusions: 1 Gunshot fractures of the humeral shaft can be adequately and comfortably evacuated in a hanging cast. 2 The hanging cast is highly satisfactory for treatment of these fractures in most instances. This method does not predispose to nonunion in cases with minor degree of bone loss. 3 Associated injuries to the nerves occur in a high percentage of these cases and are the most frequent cause of disability. 4 Ischemia due to constriction by the circular plaster is a constant danger. It can be prevented by adequate padding and splitting and spreading the plaster. 5 Secondary hemorrhage, no matter how minor, is an absolute indication for immediate exploration of the wound.

Raney⁴²⁸ in a concise well illustrated paper reviews the indications and contraindications for the use of the hanging cast. The author concludes that when reduction is necessary it should be secured by other means before the hanging cast is applied. Demonstrable weakness of the soft tissues at the shoulder, post-traumatic or otherwise contraindicates use of the hanging cast because of the danger of subluxation of the

426 Macey, H B, and Coventry, M B. Use of Hanging Casts in Compound Fractures of the Humerus, *U S Nav M Bull* 45 33-36 (July) 1945

427 Fitts, W T, Kirby, C K, and Bray, F A. Gunshot Fractures of the Shaft of the Humerus, *Surgery* 18 493-497 (Oct.) 1945

428 Raney, R B. Treatment of Fractures of the Humerus with the Hanging Cast, *North Carolina M J* 6 88-92 (Feb) 1945

shoulder joint. He also feels that in these fractures impaired mobility is more often due to changes in the soft tissues than to bony displacement and that the treatment with the hanging cast will often minimize stiffness of the shoulder.

Because he finds the current classifications of fracture of the head of the humerus, based on anatomic landmarks or relative position of the head and shaft of the humerus, unsatisfactory, Dehne,⁴²⁹ after a study of 300 fractures of the humeral head and 37 fractures of the greater tuberosity, offers a new classification based on causation. In this classification there are three main groups: fractures caused by lateral, dorsal or central mechanism. With the lateral mechanism there is an inferior dislocation and a three fragment fracture. The dorsal mechanism produces an anterior dislocation and a two fragment fracture. With the central mechanism there is a head-splitting fracture. The roentgenologic appearance is discussed, together with the clinical properties of the three types.

Kelly and Riley⁴³⁰ demonstrate by means of a model simulating a fracture through the lower third of the humerus the effect of the pull of the pronator muscle in producing varus deformity at the site of fracture. As long as the hand was pronated no deformity occurred, but when the hand was supinated lateral angulation of the distal fragment developed. They found the deformity in 16 of 24 unselected cases at the Ashford General Hospital.

Fractures About the Elbow—Sandegard⁴³¹ reports his observations in 189 cases of fracture of the lower end of the humerus in children. Of these 118 were supracondylar, 34 lateral, 3 medial condylar, 3 transcondylar and 31 medial epicondylar fractures. Most of the patients had been treated surgically with fixation by means of Russler's rust-proof nails, which were later removed. Although surgical treatment gave good results from a functional standpoint a large number of patients were found with cubitus varus or, in some instances, cubitus valgus deformities. For fractures of the medial and lateral condyles open reduction and replacement of the fragment is recommended. Removal of the fragment is generally not to be done. These cases all turned out well.

Boyer and Gale⁴³² present a general discussion of fractures of the elbow covering various types of fracture in this region and the treatment indicated for each. They point out that 80 per cent of the cases of

429 Dehne, E. Fracture at Upper End of Humerus. *S. Clin. North America* 25: 28-47 (Feb.) 1945.

430 Kelly, R. P., and Riley, J. W. Prevention of Angulation in Lower Third Humeral Fractures, *Bull. U. S. Army M. Dept.*, January, 1945, no. 84, pp. 100-101.

431 Sandegard, E. Results of Treatment of Fractures of Lower End of Humerus in Children, *Acta chir. Scandinav.* 89: 1-16, 1943.

432 Boyer, D. W., and Gale, S. A. Fracture of the Elbow, *Rocky Mountain M. J.* 42: 510-512 (July) 1945.

Volkman's ischemic paralysis occur after supracondylar and dicondylar fractures and that delayed reduction increases the danger of this complication

[Ed NOTE (L D B) This paper is an epitaph to "wait until the swelling goes down"]

"End results of fractures at the elbow are not good" With this sentence Stenstrom⁴³³ introduces his study of 213 cases which came to his attention during a six month period at an Army reception center. Most injuries to the elbow in childhood are fractures, not sprains, and unless properly diagnosed and treated may lead to serious consequences. The author's conclusions are as follows: 1 Of 213 men with positive history of injury to the elbow, 97 had disabled and deformed elbow joints. 2 Better results can be obtained by exact diagnosis followed by proper treatment. Poor results will continue to follow missed diagnosis and improper treatment. 3 Limitation of joint movement due to capsular contraction or bone block is common after injuries to the elbow. 4 After union has occurred, elbow motion should be allowed to recover at its own rate. Forcing the joint is contraindicated. 5 Subsequent growth of the bone does not correct angulations and displacements. 6 Most fractures of the elbow can be reduced satisfactorily by closed manipulation, but some require operation at the start. 7 Anatomic reduction of all fractures of the elbow is imperative.

Allen and Gramse⁴³⁴ report their results in 21 cases of supracondylar fracture of the humerus in children treated by the Dunlop traction method. The narrow oblique surface of the fracture makes retention of reduction difficult by any method other than traction. It is the rotation of the lower fragment which accounts for the alteration of the carrying angle and therefore the bad result. The traction is maintained for two to three weeks. The relatively long hospitalization is worth while to all economic groups because of the superior results obtained. In the 21 cases so treated, 8 had perfect result, 5 were not followed, 2 are too recent for classification and 2 have decreased carrying angles, 1 slight, 1 definite, but with good function in both. In the remaining 4 there was good function.

In discussing this same subject Fahey⁴³⁵ presents an analysis of 100 consecutive fractures of the elbow in children, 60 of which were supracondylar. Insertion of a screw through the upper end of the ulna for the purpose of traction is recommended for certain displaced supracondylar fractures, where closed manipulation fails.

433 Stenstrom, J D. Elbow Fractures, *Canad M A J* 52:48-55 (Jan) 1944

434 Allen, P D, and Gramse, A E. Transcondylar Fractures of the Humerus Treated by Dunlop Method. *Am J Surg* 67:217-227 (Feb) 1945

435 Fahey, J J. Fractures of the Elbow in Children, *S Clin North Am* 25:59-80 (Feb) 1945

An excellent review of over 700 cases of fractures about the elbow in children 12 years of age or younger is presented by Boyd and Attenberg.⁴³⁶ Damage to the nerves and blood vessels, which frequently accompanies these fractures, is often of greater consequence than the fracture itself. For this reason they caution the surgeon to ascertain the state of the nerve and blood supply to the arm before reduction and afterward. The authors give five types of fractures occurring about the elbow in children, and discuss each in a separate section.

Curry⁴³⁷ gives a partial review of the literature on excision of the elbow and reports a case. The patient sustained a compound comminuted fracture of the elbow joint. At operation it was impossible to reduce the fracture and hold the fragments together. A complete excision was therefore decided on and carried out. The postoperative convalescence was uneventful, and the patient returned to light duty on the fortieth postoperative day. There was no pain, the elbow was flail and unstable but useful. Roentgenograms to show shape and range of motion are included in the article.

Fracture of the Head of the Radius—Closed reduction of fractures of the neck of the radius in children is discussed by Goldenberg,⁴³⁸ who recommends the manipulative technic described by Patterson in 1934. The author reports 4 cases, in all of which the head was reduced. In 1 case three attempts were made before reduction was accomplished. The fracture healed and excellent function resulted in 3 cases.

For comminuted fracture of the head of the radius without pronounced displacement Postlethwait⁴³⁹ recommends aspiration of the hemarthrosis followed by injection of 5 to 8 cc of 1 per cent procaine and active mobilization. The patient wears the arm in a sling and is instructed to exercise the arm within the limits of pain four times a day for twenty minutes each time during the first seven days. After this the sling is removed and the patient begins light tasks. Fourteen patients were treated in this manner and all made an excellent recovery except 1, who had a loss of about 5 per cent in carrying angle.

Fracture of the Forearm—In an excellent résumé of fractures of both bones of the forearm Compere⁴⁴⁰ reviews the anatomy of the forearm

436 Boyd, H. B., and Attenberg, A. R. Fractures About the Elbow in Children. *J. Tennessee M. A.* 38: 243-251 (Aug.) 1945.

437 Curry, G. J. Excision of the Elbow for Multiple Compound Comminuted Fractures. *Am. J. Surg.* 70: 243-248 (Nov.) 1945.

438 Goldenberg, R. R. Closed Manipulation for the Reduction of Fractures of the Neck of the Radius in Children. *J. Bone & Joint Surg.* 27: 267-273 (April) 1945.

439 Postlethwait, R. W. Modified Treatment for Fracture of Head of Radius. *Am. J. Surg.* 67: 77-80 (Jan.) 1945.

440 Compere, E. L. The Treatment of Fractures of Both Bones of the Forearm. *S. Clin. North America* 25: 48-58 (Feb.) 1945.

and types of fractures and lists as essentials in treatment (1) restoration of length, (2) accurate apposition of fracture surfaces, (3) correction of alinement, (4) wide separation between radius and ulna at site of fracture, and (5) complete immobilization with elbow at 90 degrees from metacarpophalangeal joints to well above the elbow, the forearm being completely supinated for fractures above pronator radii teres, or in midsupination, pronation for fractures distal to this insertion. Oblique fractures may be treated by continuous traction, some type of fixed skeletal traction or open reduction and plating. Old ununited fractures should be grafted. Recent compound ones need debridement and thorough cleansing (plating optional). Old infected fractures are treated by the Orr method.

[ED NOTE (L D B) Plating of forearm fractures as in other fractures frequently leads to nonunion. In forearm fractures intermedullary wires as described by James Dickson give adequate immobilization and do not interfere with union.]

Fixation of fractures of the metacarpal and forearm bones by means of a Kirschner wire driven into the medullary canal is recommended by Long and Fett⁴⁴¹ as being consistent with principles of good treatment. The advantages are accurate reduction, absolute immobilization and early finger motion. The technic is described. In 12 patients treated by this method there was early development of callus. All healed in anatomic position, and none had stiffness of fingers.

Evans⁴⁴² discusses rotational deformity in fractures of both bones of the forearm and describes a method whereby the correct rotational position in which to immobilize the fracture may be determined.

Stuck⁴⁴³ considers the treatment of fractures of the forearm from the anatomic and mechanical viewpoint. This is a good paper and should be read by all who are interested in the details of treatment as related to the cause of fractures.

Fracture at the Wrist—An excellent article by White⁴⁴⁴ on Colles' fracture is summed up as follows: 1 Do not attempt reduction without roentgenograms. 2 Do not attempt reduction without anesthetic, preferably general. 3 Do not stop short of anatomic reduction. 4 Do not use splints, if plaster is available. 5 Do not remove the cast too soon. 6 Remember to tell the patient to move his fingers. [ED NOTE (L D B) And remember to move his shoulder.] 7 Do not

441 Long, R. D., and Fett, H. C. Medullary Canal Wire Transfixion in Metacarpal and Forearm Fractures, U. S. Nav. M. Bull. 44: 253-256 (Feb.) 1945.

442 Evans, E. M. Rotational Deformity in the Treatment of Fractures of Both Bones of the Forearm, J. Bone & Joint Surg. 27: 373-379 (July) 1945.

443 Stuck, W. G. Anatomical and Mechanical Aspects of Treatment of Fractures of the Forearm, Texas State J. Med. 42: 232-240 (Sept.) 1945.

444 White, J. W. Colles' Fracture, South. M. J. 38: 415-417 (June) 1945.

use too strenuous physical therapy actively or passively 8 Do not resort to subsequent surgical treatment in older persons

Attention is again called to delayed rupture of the extensor pollicis longus tendon following Colles' fracture Coburn⁴⁴⁵ reports such a case, in which the extensor carpi radialis longus tendon was transplanted into the distal end of the ruptured tendon with excellent results His studies indicate that the lesion occurs on an average of once in every 250 cases, usually in women between 25 and 40 years of age Cause of the rupture seems to be both trauma to the tendon and interference with its blood supply sustained at the time of fracture

Ymaz⁴⁴⁶ calls attention to the relative frequency of fractures of the carpal scaphoid in military services Ninety-six of such fractures were treated between 1939 and 1943 Immobilization until the fracture is completely consolidated is emphasized

Meekison⁴⁴⁷ in a well written paper discusses fractures of the carpal scaphoid, fractures of the head of the radius and fractures of the medial malleolus He considers fractures of the carpal scaphoid under two headings fresh fractures (not a problem) and old fractures (a problem) Good results should be obtained in fresh fractures by closed methods in all cases In old fractures there are four methods to consider immobilization, excision, bone graft and arthrodesis of the wrist Immobilization is used in fractures one to three months old which are accurately reduced They should be kept up until union has occurred, or for four to six months Excision is reserved for the fragment which shows evidence of aseptic necrosis Bone graft was used by the author in 17 of his 115 cases Arthrodesis gives a strong painless wrist In discussing fractures of the head of the radius he emphasizes early operation and motion of the arm as soon as possible after surgical treatment

Hambly⁴⁴⁸ emphasizes that sprain of the wrist is clinically rarer than a fractured wrist and that therefore all sprained wrists should be examined roentgenologically The scaphoid may be fractured at the proximal pole, the wrist or the tubercle Aseptic necrosis occurs in about one third of all cases of fracture of the scaphoid through the proximal pole in spite of early treatment Treatment of all three types

445 Coburn, D E Delayed Rupture of the Extensor Pollicis Longus Tendon Following Colles' Fracture, *Am J Surg* 68 234-239 (May) 1945

446 Ymaz, J I Tratamiento de las fracturas del escafoides carpiano *Rev san mil*, Buenos Aires 43 1284-1289 (Sept) 1944

447 Meekison, D M Some Remarks on Three Common Fractures I Fracture of the Carpal Scaphoid, II Fractures of the Head of the Radius, III Fractures of the Medial Malleolus, *J Bone & Joint Surg* 27 80-84 (Jan.) 1945

448 Hambly, E H T Fractures of the Carpal Scaphoid *M Press* 213 260-263 (April 25) 1945

of fresh fractures is by prolonged immobilization. In cases of established nonunion drilling or grafting of the fragments may be employed. The author prefers drilling.

A sharp warning against making a diagnosis of sprained wrist is also sounded by Soto-Hall.⁴⁴⁹ This article is enhanced by photographs showing the reduction procedure and application of the plaster cast. The author discusses the different types of fracture and the methods of handling each one, stating that the methods suggested are not new but have stood the test of time. He believes that in 95 per cent of the cases healing will occur within four to five months, and if it does not prolonged immobilization is not recommended, because there are complications present which should be treated surgically. When fracture of the scaphoid is associated with luxation of the semilunar (this occurs in about 12 per cent of the cases) the wrist should be held in slight volar flexion for the first four weeks. Otherwise there may be a redislocation of the semilunar bone.

Kaplan⁴⁵⁰ calls attention to the common observation that when traction is applied to the entire finger for treatment of a fracture of the corresponding metacarpal, stiffness will develop regardless of the type of traction. He recommends reduction of the fracture with the patient under local anesthetic and traction applied through the proximal phalanx of the fractured metacarpal by means of a traction wire drilled through the bone and the use of a Granberry finger bow. The entire procedure is well described and illustrated.

[ED NOTE (L D B) Infection about the site of wire traction in a finger may lead to serious disability.]

Barba Inclan A.⁴⁵¹ reports 4 cases of metacarpal fractures in which treatment was by the method of Eugene F. Berkman of the United States Army. The fracture is reduced with the patient under local anesthesia, after which a heavy Kirschner wire is introduced through the fractured bone and the adjacent metacarpals in such a way as to fix the fracture. For oblique or spiral fractures two or more wires are used. No post-operative cast or splinting is necessary. Function of the hand is preserved and the convalescent period is shortened. This method is not suited to fractures of the first metacarpal.

[ED NOTE (L D B) The complications from such therapy may lead to more serious disability than would less accurate reduction and fixation.]

449 Soto-Hall, R. Recent Fractures of the Carpal Scaphoid, *J A M A* 129 335-338 (Sept 29) 1945

450 Kaplan, E. B. Treatment of Fractures of Metacarpals and Proximal Phalanx by Skeletal Traction, *Bull Hosp Joint Dis* 5 99-109 (Oct) 1944

451 Barba Inclan. Tratamiento de las fracturas de los cuatro últimos metacarpianos, por fijación interna, *Cir ortop y traumatol*, Habana 12 72 76 (April June) 1945

Vasko⁴⁵² describes a simple method for reducing fractures of the neck of the metacarpals by flexing the metacarpophalangeal joints to a right angle and forcibly pushing back on the proximal phalanx against the metacarpal head, counterpressure on the metacarpal being maintained. When the fracture is reduced the finger and the hand are splinted in this position by adhesive strapping. The author reports a series of about 88 cases in which this treatment was used with good results. Fixation is maintained for three to four weeks. In 3 cases displacement recurred. Two patients removed the tape but reduction was successfully accomplished a second time. In the third case the patient did not return until union was present, and some deformity was the result.

[Ed NOTE One of the reviewers (L. D. B.) has found a similar method, plaster being used in place of adhesive tape, most satisfactory. The finger must be observed for pressure symptoms over the proximal interphalangeal joint.]

Hipps⁴⁵³ reports a case of dislocation of the base of the fifth metacarpal and states that a study of the literature reveals that only 9 cases have been previously reported. Signs include the tendency for the fifth finger to spread away from the fourth, shortening of the fifth finger and tenderness around the base of the fifth metacarpal. Roentgenograms reveal the dislocation.

Reduction was easy but difficult to maintain. It was accomplished, however, by means of two nonpadded plaster splints applied in such a way as to maintain constant pressure over the base of the fifth metacarpal. Fixation was maintained for six weeks, and the final result was excellent. The author discusses the types of dislocation previously reported and gives an analysis of the literature.

An almost identical case is presented by Clement,⁴⁵⁴ except that in this instance reduction could not be maintained. Plaster of Paris was thought to be inadequate, and a Kirschner wire was inserted in the proximal third of the metacarpals to the little, ring and middle fingers. Following this, fixation was stable and the normal appearance of the hand was restored. The patient made an uneventful recovery.

Miscellaneous—For fixation of small, fragile bone fragments in fractures in which exact position of the fracture is essential Herzog⁴⁵⁵ has devised a special method. A spiral Kirschner wire (1.5 mm in diameter) is drilled through the fragments and diagonally through the

452 Vasko, J. R. Metacarpal Neck Fractures, *Mil Surgeon* **97** 121-122 (Aug) 1945

453 Hipps, H. E. Simple Isolated Dislocation of the Fifth Metacarpophalangeal Articulation *U. S. Nav. M. Bull.* **45** 945-950 (Nov) 1945

454 Clement, B. L. Fracture-Dislocation of the Base of the Fifth Metacarpal. A Case Report *J. Bone & Joint Surg.* **27** 498-499 (July) 1945

455 Herzog, K. Methode zur Osteosynthese kleiner brüchiger Knochenstücke, *Chirurg* **15** 669-672 (Nov. 15) 1943

bone from which they have been separated in the process of fracture. The wire is left in place and the operation completed by securing the ends of the wire. It is left in position until healing is complete and then removed through two small incisions. The author illustrates his procedure with drawings and roentgenograms.

Bate⁴⁵⁶ describes an operation to prevent locking of the proximal interphalangeal joint of the fifth finger in hyperextension. The procedure consists of suturing the torn volar ligament and repairing the lateral capsule in such a way as to shorten the volar surface by suturing the capsule more proximally. An excellent result was obtained in an aviator who was unable to operate the throttle control on a four motor plane because of locking of the fifth finger in hyperextension.

Cutting⁴⁵⁷ in discussing injuries of the hand in working men stresses the importance of respecting all injuries, even small and apparently insignificant ones. They should receive meticulous and intelligent care. In his conclusions the author emphasizes the following points: (1) early definitive care of fractures of the hand, since they must be considered surgical emergencies, (2) accurate reduction, and traction when necessary, and (3) the use of nonpadded, well molded plaster splints which provide maximum immobilization of the fragments, and yet allow maximum function and use of the noninjured portion of the hand.

Murray⁴⁵⁸ recommends wires placed longitudinally in the medullary canal of the clavicle, the radius and the ulna, and in some cases of the humerus and the long bones of the hands and the feet, as providing a method of treatment which gives improved results in these fractures. In many cases the wires can be introduced after closed reduction, otherwise a small incision is made.

A series of 154 cases representing various types of fractures is reported. In these cases there was no evidence that Kirschner wires of small or medium size traversing the articular cartilage harm the joint. There was no migration of wires placed in bones even though they cross joints. In only 1 case was there infection.

FRACTURES OF THE LOWER EXTREMITY

Fractures About the Hip Joint—Ellis⁴⁵⁹ reports 44 cases of war wounds in the region of the hip joint, expressing his dissatisfaction with

456 Bate, J. T. An Operation for the Correction of Locking of the Proximal Interphalangeal Joint of Finger in Hyperextension, *J. Bone & Joint Surg.* 27: 142-144 (Jan.) 1945.

457 Cutting, C. C. Hand Fractures in Industry, California & West. Med. 62: 21-22 (Jan.) 1945.

458 Murray, G. Use of Longitudinal Wires in Bones in the Treatment of Fractures and Dislocations, *Am. J. Surg.* 67: 156-164 (Feb.) 1945.

459 Ellis, J. S. Wounds in Region of Hip-Joint, *Lancet* 2: 490-492 (Oct. 20) 1945.

the results on the whole. He discusses in some detail treatment including various types of splintage with comparison of different methods, and suggestions for improvement. The results are closely analyzed as to causes for unsatisfactory results, which included shortening, slow healing, chronic infection and prolonged mobility, with an earnest effort to devise methods for improved results. After this careful analysis, he presents recommendations here epitomized: (1) early treatment of the wound with moderate debridement and removal of foreign material, (2) delayed primary or secondary closure, (3) early decision as to desirability of ankylosis, with (a) application of a spica to the hip if it is to be ankylosed or (b) traction if motion is to be preserved, and (4) prompt definition of complications such as foreign body, sequestrum and abscess cavity, with early, adequate and, if necessary, radical surgical treatment.

Sonnenschein⁴⁶⁰ describes a series of cases of what he calls "dashboard acetabular injuries," caused by the current practice of riding in a car with the hips flexed and the knees against the instrument panel. In this position, the thrust of the car against the knee transmits the power through the femoral head against the shallow posterior rim of the acetabulum. Thus the hip is dislocated, the acetabulum fractured, or both, depending on the degree of violence plus the angle of impingement. He discusses two common complications: first, injury to the sciatic nerve, which must be treated appropriately, and, second, aseptic necrosis of the head and the neck of the femur. To prevent the latter, early reduction of dislocation of the head plus three weeks of protection in bed is suggested, with further protection as indicated.

[ED NOTE (L D B) If the circulation to the head and the neck of the femur has been disturbed it is difficult to determine the length of time that weight bearing should be avoided and traction should be continued in the treatment of dislocation of the hip. Frequently roentgenograms will not show signs of aseptic necrosis under a year or more. It is hoped that the Surgeon General's Office will prepare a report on the results obtained in the treatment of a large series under controlled conditions and if possible an opinion as to the effect of early weight bearing.]

MacAusland and Lee⁴⁶¹ discuss fractures of the acetabulum, particularly (1) fractures of the superior-posterior rim and (2) central fractures. Three cases are presented with internal fixation of the fragment of the hip. Late result after two years of apparent success was necrosis of the femoral head, plus later destruction of the hip joint. The

⁴⁶⁰ Sonnenschein, H. D. Dashboard Acetabular Injuries. *Bull. Hosp. Joint Dis.* 5: 60-70 (Oct.) 1944.

⁴⁶¹ MacAusland, W. R. and Lee, H. G. Fractures of the Acetabulum. *Am. J. Surg.* 69: 213-220 (Aug.) 1945.

authors believe that the surgical treatment of fractures of the acetabular rim is advisable to shorten convalescence and hasten healing. One case is presented in detail of central fracture with general discussion of treatment, including various methods of obtaining lateral pull by screw, pin and bolt. In these cases long follow-up will frequently show disappointing results with destruction of the hip joint.

Haas⁴⁶² describes a case of fracture dislocation of the hip with a portion of the head remaining in the acetabulum. He discusses the *difficulties of treatment with inevitable disability*. In his case treatment was by excision of fragment and reposition of remaining head. Later there were excision of the fragment of the head, which had fractured subsequent to reduction, reconstruction and fusion, all of which failed. He leans toward early reconstruction if simple excision of the fragment fails.

A case is reported by Abbate⁴⁶³ of an old fracture of the ischial tuberosity by avulsion. This had been undetected and was untreated with poor result early but with improved condition following conservative treatment later. He advises surgical intervention only for persistent disability.

An ambulant cast with caliper attachment and hinged knee brace is described by Phalen⁴⁶⁴ for use in those cases in which it is desirable to protect the hip with a cast but still permit motion at the knee and the ankle to prevent stiffness. The apparatus consists of a short spica (plaster) with embedded metal bars to receive bars for a brace with drop ring knee and caliper heel. He urges its use to prevent prolonged immobilization of the knee in chronic conditions resulting from compound injuries about the hip.

Intertrochanteric Fractures—Posch and Abbott⁴⁶⁵ refer briefly to recent excellent summaries on various types of treatment for intertrochanteric fractures, including (1) external splints, (2) traction devices and (3) internal fixation. These authors conclude that internal fixation is the method of choice if available. However, in many instances—namely, poor surgical risk or severe coma—internal fixation may not be feasible. They report 14 cases of this type, in which treatment was carried out by use of the hanging cast. The patients were from 48 to 91

462 Haas, S. L. Longitudinal Fractures of Head of Femur Associated with Dislocation of Femur. *Am J Surg* 69:402-405 (Sept.) 1945.

463 Abbate, C. C. Avulsion Fracture of the Ischial Tuberosity. A Case Report, *J Bone & Joint Surg* 27:716-717 (Oct.) 1945.

464 Phalen, G. S. A Cast-Caliper Brace for Immobilization of the Hip. *J Bone & Joint Surg* 27:724-726 (Oct.) 1945.

465 Posch, J. L., and Abbott, W. E. Treatment of Intertrochanteric Fractures of the Femur. Use of the Hanging Cast, *Am J Surg* 70:370-373 (Dec.) 1945.

years old. As described by Johnson, the method can be carried out with the patient under local anesthetic and is a simple procedure. A detailed description of the method is given, mortality was 2 per cent, with results comparing favorably with all other methods except internal fixation. Since these cases were selected because internal fixation seemed inadvisable, the authors conclude that the method has merit.

[**ED NOTE** This method of treatment would seem to be well adapted to another group of cases, namely, those in which a skilled surgical team with adequate operating facilities was unavailable.]

Cohn and Vonburg⁴⁶⁶ state that "treatment of intertrochanteric fractures of the femur has lagged behind the development of internal fixation for fractures of the femoral neck. It is generally assumed that fractures in the region of the trochanters will heal regardless of position and method of treatment. This false assumption is based on the rich blood supply of the extracapsular area as compared with the poor vascularization of the intracapsular or femoral neck region. Although healing takes place in a higher percentage of intertrochanter cases than in neck fractures, nonunion does occur, as the authors have observed. Much more important than the occasional case of non-union is mal-union, the percentage of the latter being surprisingly high." The authors describe in detail the technic for insertion of a blade plate, which they feel is superior to other types of devices for internal fixation. Careful selection of cases must be made to avoid disappointing complications.

Fractures of the Neck of Femur—Many good articles were published on this subject in 1945, but no radical changes or startling ideas have been presented. Rather have there been suggested refinements of technic or reports of isolated unusual cases. Duhamel⁴⁶⁷ reports success with the use of a roentgenographic guide consisting of a bent (90 degree) metal plate as described by Huet and Huguer. Godoy-Moreira⁴⁶⁸ adds 80 patients to the series reported in 1940, he used his special stud bolt screw and made considerable simplification of technic and instruments. He reemphasizes that the good results obtained are due to the firm impaction secured by the stud bolt screw. However, he suggests the use of a short spica cast for a few weeks subsequent to the first three weeks after the operation. [**ED NOTE** Altogether this seems to be an extremely efficient method for internal fixation in the hands of one familiar with its use.]

⁴⁶⁶ Cohn, B. N. E., and Vonburg, V. R. The Surgical Treatment of Intertrochanteric Fractures, *Rocky Mountain M J* **42** 587-592 (Aug) 1945

⁴⁶⁷ Duhamel, B. Indications vitales et technique de l'enclouage du col femoral, *Presse med* **53** 267-268 (May 26) 1945

⁴⁶⁸ Godoy-Moreira, F. E. Difficult Fractures of the Neck of the Femur Treated with Stud-Bolt Screw, *J Bone & Joint Surg* **27** 595-602 (Oct) 1945

Gervis⁴⁶⁹ suggests the use of a modified Smith-Peterson nail to prevent the complication of extrusion of the nails. He comments on the fact that fixation of the head of the nail into the femoral cortex is not advisable since it may lead to distraction of the fragments or impingement of the nail into the acetabulum. He aims at securing fixation at the point of the nail and provides this by notching each flange about $\frac{1}{4}$ inch (0.64 cm) from the point. It was hoped that these notches would serve to fix the point of the pin in the femoral head. The method has been tried successfully in 24 cases. The author comments that after union has occurred, there is no difficulty in withdrawing the pins.

Rowe⁴⁷⁰ describes a new type of guide wire for insertion of internal fixation into the femoral neck.

[ED NOTE This pin seems to have considerable merit, and for the technical details of construction of pin and its use one should carefully study the original article.]

Heyman⁴⁷¹ reports a case of bilateral fractures of the femoral neck occurring fourteen and seventeen months respectively after extensive irradiation for a carcinoma of the cervix. In neither hip was there direct trauma. Neither showed signs of metastasis. Each was pinned promptly with a Smith-Peterson nail, and both responded promptly and well to internal fixation and two years later were still well healed with no evidence of necrosis. Heyman attributes the good results to prompt and efficient internal fixation.

Virgin and MacAusland⁴⁷² discuss in detail a "continuous traction screw" for fractured femoral neck (for details the article should be consulted). They report follow-up on 17 cases with 76.8 per cent of bony union. They emphasize particularly the importance of maintenance of firm apposition by the spring traction inherent in the screw.

Leadbetter⁴⁷³ reviews carefully the whole history of the fractured hip, pointing out the tremendous advance due to internal fixation. He advises great attention to the patient's general condition and says that this is as important as is good operative technique. This whole

469 Gervis, W. R. A Modified Smith-Peterson Nail for Fractures of the Neck of the Femur, *Proc. Roy. Soc. Med.* 38:615-616 (Sept.) 1945.

470 Rowe, M. L. A Simple Guide Pin for the Insertion of Devices of Internal Fixation into the Femoral Neck, *J. Bone & Joint Surg.* 27:522-223 (July) 1945.

471 Heyman, C. H. Spontaneous Bilateral Fracture of the Neck of the Femur Following Irradiation, *J. Bone & Joint Surg.* 27:674-678 (Oct.) 1945.

472 Virgin, H., Jr., and MacAusland, W. R. A Continuous Traction Screw for Fixation of Fractures of the Hip. Review of Twenty-Three Cases, *J. Surg.* 122:59-67 (July) 1945.

473 Leadbetter, G. W. The Problem of the Fractured Hip, *Nebraska M. J.* 30:309-313 (Sept.) 1945.

problem of the patient must be considered rather than just the reduction and fixation

Golodner, Morse and Angrist⁴⁷⁴ report in detail 304 cases of fractures of the hip with 86 deaths (28 per cent). Two thirds of the deaths were in patients between 70 and 80 years of age. Necropsy in 25 cases revealed pulmonary embolism in 9 and bronchopneumonia in 8. Thus, 68 per cent showed definite pulmonary cause of death which in 53 per cent of these was due to embolism. They conclude "1 Pulmonary embolism from venous thrombosis in the vessels of the lower extremities is the most frequent cause of death in cases of fracture of the hip. 2 Venous thrombosis and embolism are less frequent in patients who are made ambulant early. 3 Prophylactic bilateral superficial femoral vein ligation combined with lumbar sympathetic block is suggested as most ideal for the prevention of pulmonary embolism in fractures of the hip, especially in those who cannot be made ambulant at an early date.

Henderson and Hinchey⁴⁷⁵ report on the Colonna reconstruction operation and discuss the details of the technic including after-care, both immediate and late. Some modification of technic was suggested. Out of 22 cases with complete follow-up results were excellent in 31 per cent, good in 23 per cent, fair in 23 per cent and poor in 23 per cent. The operation is recommended for selected cases.

Fractures of the Shaft of the Femur—That the problem of the fractured femoral shaft is still not satisfactorily solved is attested by the usual large series of articles covering this subject. No fewer than thirty articles on fractures of the femur were reviewed, and over half of these concerned fractures of the shaft. To reveal the continuing trend away from external skeletal fixation (Stader and Haynes type), no one of these authors mentioned this except to condemn it. McKeever⁴⁷⁶ reports 47 cases in which treatment had previously been given elsewhere: one half by traction, two sixths by internal fixation and one sixth by external skeletal fixation. A careful analysis in regard to time of recumbency, time of protection, roentgenologic evidence of union, degree of shortening, degree of atrophy and other complications is made. He concludes that, in the average hospital by the average surgeon, traction is the best method. Many authors discuss various methods for obtaining traction. James⁴⁷⁷ reports a general

474 Golodner, H., Morse, L. J., and Angrist, A. Pulmonary Embolism in Fractures of the Hip, *Surgery* 18 418-423 (Oct.) 1945

475 Henderson, M. S., and Hinchey, J. J. The Colonna Reconstruction Operation for Ununited Fractures of the Neck of the Femur, *Minnesota Med.* 28 641-644 (Aug.) 1945

476 McKeever, F. M. Femur Fractures. Fracture of Shaft in Adults, Evaluation of Methods of Treatment, *J. A. M. A.* 128 1006-1012 (Aug. 4) 1945

477 James, E. S. Treatment of Fractures of the Shaft of the Femur. *Manitoba M. Rev.* 25 48-49 (Feb.) 1945

review of various types of traction used in various age groups and locations Von Susani⁴⁷⁸ discusses at some length the various methods of traction and discusses a method of intrinsic traction within a splint (much like the Siebrandt frame) which obviates the necessity for fixation of the apparatus, and hence the patient, to the bed Traction is obtained by suitable springs and weights within the suspension splint itself Modlin,⁴⁷⁹ in discussing fractures of the lower part of the femur, recommends double traction with a Kirschner wire through the upper part of the tibia for linear traction plus a second Kirschner wire through the lower femoral fragment to control rotation of this fragment Deacon⁴⁸⁰ describes in detail four fractures of the lower part of the femur, three of them including separation across part of the lower epiphyseal plate with split up the shaft Results were only fair with conservative measures such as traction, manipulation and cast [Ed NOTE The disturbance in growth noted in these cases may often be prevented by prompt, accurate replacement, surgical if necessary, of the dislocated epiphysis] Fisk⁴⁸¹ favors the use of a suspension traction splint similar to the Tobin splint, with weight so arranged as to permit constant exercise to prevent stiffness of the knee in fractures of the shaft and reports 33 cases in which it was used successfully Tavernier⁴⁸² describes in detail an operation to release the stiff knee should stiffness occur He reasons that the restriction of motion is due to adhesions in the suprapatellar pouch and between the patellar edges and the femur The plastic operation is designed to release the patella on both sides, split the patellar tendon, free the pouch laterally and flex the knee It seems a formidable procedure but in the author's hands was rather successful [Ed NOTE One wonders whether patellectomy would not simplify the procedure and hasten convalescence] Van Domselaar⁴⁸³ recommends the manipulation method popularized years ago by the late Willis Campbell He advocates reduction of the fracture of the shaft with application

478 von Susani, O Ueber die Dauerzugbehandlung von Ober- und Unterschenkelbrüchen mit besonderer Berücksichtigung der Schussverletzungen *Deutsch-Ztschr f Chir* 258 363, 1945

479 Modlin, J Double Skeletal Traction in Battle Fractures of Lower Femur, *Bull U S Army M Dept* 4 119-120 (July) 1945

480 Deacon, A E. Fractures of the Lower Third of the Femur, *Maritime M Rev* 25 45-48 (Feb) 1945

481 Fisk, G R La fractura de la diáfisis femoral Nueva aportación al problema, *Prensa med argent* 31 2433-2437 (Nov 29) 1944

482 Tavernier, L Technique de la cure opératoire des raideurs du genou après les fractures du fémur traitées par traction sur broche de Kirschner, *Lyon chir* 40 9-14 (Jan-Feb) 1945

483 van Domselaar, F Fractura de diáfisis femoral Tratamiento por yeso, *Rev med d Hosp brit* 1 15-20 (Oct) 1944

or a long single or short double hip spica. Westerborn⁴⁸⁴ reports 28 cases in which Kuntscher's method of intramedullary nailing was used. Half were recent fractures, and half pseudarthrosis. The method may be used for any type of fracture but in most cases he advises open visualization of the fracture rather than closed manipulation. Especially in pseudarthrosis it is necessary to freshen up the fracture line and obtain revascularization to promote healing. The author discusses various advantages of the method and seems well convinced of its efficacy. A second grouping of cases of fracture of the femur concerns compound fractures, particularly war injuries. Collom and Ewing⁴⁸⁵ in a complete and careful study report 100 cases divided into four groups:

Group I. Twenty battle fractures treated without wound closure or penicillin therapy by skeletal traction. Group II (a) Nine battle fractures treated the same as group I that became septic and were then treated by surgery and penicillin therapy. Five had delayed internal fixation with bone plates. (b) Forty-one battle fractures treated by wound closure with drainage and penicillin therapy. Eleven were treated by bone plate fixation, the remainder by skeletal traction. Group III. Twelve battle fractures treated by wound closure (without drainage in 11). Delayed internal fixation by plating was done in 3 cases, 9 being treated by skeletal traction. Group IV. Eighteen simple fractures treated by skeletal traction. Four required delayed open reduction and plating. From the standpoint of wound healing and fracture alignment, definitive surgery consisting of secondary closure of wounds with drainage and skeletal traction has been most satisfactorily instituted in the period from five to ten days after injury. In the cases of Group I, where surgical closure of wounds was not performed, infection developed by secondary invasion even in those which were previously non-suppurative. These injuries required wound revision and excision of devitalized tissue. Tissue closure was best attained by deeply placed interrupted vertical mattress sutures of silk in the skin. Proper dependent drainage should be a routine procedure. Internal fixation with vitallium plate and screws was done in twenty-four cases. Twenty of these were done in compound fractures and four in simple fractures. Open reduction of compound fractures can be safely performed under penicillin protection even in the presence of infection as was done in five cases in Group IIa. Twenty-three of the cases on which internal fixation was done obtained good results. In the other case there was loosening of the screws because of poor technique requiring removal of the plate, osteotomy and application of a second plate. The ultimate result in this case was satisfactory.

The indications for internal fixation in this group of cases, are given. Although open reduction with internal fixation was performed in 24 per cent of the compound fractures, excellent alignment was obtained by traction in the most severely comminuted fractures.

484 Westerborn, A. Nailing in Marrow Cavity in Cases of Recent Fracture and Pseudarthrosis. Report of Twenty-Eight Cases. *Acta chir Scandinav* 90: 89-104, 1944.

485 Collom, S. A., Jr., and Ewing, W. M. A Comparative Study of One Hundred Fractures of the Shaft of the Femur. *Ann Surg* 122: 773-792 (Nov.) 1945, *M. Bull. Mediterranean Theat. Op.* 3: 37-39 (Feb.) 1945.

Wound healing in twenty-nine cases treated by the open method (Group I and IIa) was unsatisfactory with exudation for over two months in twenty-six of the patients. In the other fifty-three soldiers with compound femoral fractures wound healing by primary intention resulted in two thirds of the cases and all wounds were healed in an average time of four weeks. The other one third of the cases in this group healed by secondary intention without systemic complications. In the nine cases of sepsis treated with delayed penicillin therapy temperature elevation persisted for fifty-six days after admission. In the presence of abscess formation or necrotic tissue penicillin was not a curative agent nor does it prevent systemic signs of infection. Although infection in the wound did not materially affect the appearance of callus on roentgenologic examination, delayed union of bone was in direct proportion to the length of time drainage persisted. As far as can be demonstrated from the groups of cases, bone healing was not accelerated by the use of penicillin except in its role of controlling invasive infection. [There were] no deaths or amputations in this hospital among patients with femoral shaft fractures.

[ED NOTE This study is a thoroughly analyzed and carefully reported series, reported without prejudice, and well merits consultation of the original article.]

Burns and Young⁴⁸⁶ report 70 cases of compound fracture in which treatment was with penicillin. In 48 of these the wounds were closed secondarily within three to ten days and without drainage. The rate of healing and restoration of function in these cases equaled that of closed fractures. The authors decry the use of drainage in these cases as prolonging healing and encouraging suppuration. The patients had good primary care and reached the authors in good condition and were operated on promptly. There were no deaths or amputations and there was no general sepsis after operation. McEwen, Bickerton and Pilcher⁴⁸⁷ report 64 cases completely in accordance with the foregoing. Better results were obtained when wounds were sutured than when they were left open, best results were obtained when wounds were closed between the sixth and the tenth day after wounding. The rate of healing improved when a ten day course of penicillin was substituted for a five day course (average of twenty-seven days against forty-three). Intramuscular administration of sodium penicillin did not retard the rate of union of fractures, and the presence of metallic foreign bodies did not affect materially the prospects of healing. So good was the work of the forward surgeons in the central Mediterranean command that most wounds complicated by major fractures reached the center clean enough for prompt closure without reopening or drainage.

486 Burns, B. H., and Young, R. H. Compound Fractured Femur, Treated with Aid of Penicillin, *Lancet* 1 236-238 (Feb 24) 1945

487 McEwen, R. J. B., Bickerton, J. G., and Pilcher, M. F. Compound Fractures of Femur. Two-Stage Operation, *Lancet* 1 623-624 (May 19) 1944

extensor defect, angulation of fragments and arthritis. He comments that although these are old cases he doubts whether recent cases are much better, since methods have not changed except for refinements of technic. [ED NOTE. This is a thought-provoking report. Perhaps patellectomy, partial or complete, is the answer.]

Fractures of Shaft of the Tibia and Fibula—Lathrop⁴⁹¹ reviews in some detail the anatomy of the lower part of the leg and the physiology of bone healing. As the title indicates, he emphasizes the importance of complete, accurate immobilization, plus continuous and firm fixation. He reviews the various salient features of the individual fracture with suggestions as to their care. A detailed discussion of the place and relative merits of casts, traction and internal fixation is given, together with a plea for better care.

Gervis⁴⁹² recommends internal fixation for oblique fractures of the lower third of the tibia and especially advocates use of one long screw across the obliquity.

[ED NOTE. It would seem that if the fracture is exposed surgically, more adequate fixation than one screw could be readily used.]

Pease⁴⁹³ has used the beaded Kirschner wire, developed by Thomson and Ferciot (*Surg., Gynec. & Obst.* 64: 831, 1937) in 68 cases of fracture of the leg, with no instance of nonunion or infection. He considers it a procedure which should be in the armamentarium of all those who treat fractures. It has its limitations, but likewise its advantages. It requires no expensive equipment. Reductions can be attained with trained assistants. It diminishes the number of open reductions or thereby avoiding vascular interference and possible infection. No material is left in the bone. The patient may be ambulatory. Recovery from the anesthetic is accomplished. Not only good but also good functional result is obtained. Oblique and spiral "bumper" fractures, tibiofibular dislocations and open reduced plateau fractures are ones best suited for its application.

Funsten and Lee⁴⁹⁴ in a scholarly article discuss 149 cases of fracture of the tibia and fibula and femur. The original article should be read, but the following conclusions are understood.

1. The long bones of the lower extremity are the biggest and strongest in the body. The force required to break them must necessarily be great.

491 Lathrop M. R. The Importance of Accurate Reduction and Immobilization of Fractures of the Lower Leg. *Nebraska Medical Journal* (April) 1945.

492 Gervis W. H. A One Screw Technique in Oblique Fractures of the Tibia, *Proc. Roy. Soc. Med.* 38: 616 (Sept.) 1945.

493 Pease C. N. Beaded Wires in Treatment of Fractures of the Leg, *S. Clin. North America* 25: 174-191 (Feb.) 1945.

494 Funsten R. V. and Lee R. W. Healing Time in Fractures of the Tibia and Femur. *J. Bone & Joint Surg.* 27: 397-404.

the damage taking place at the time of injury is not only in the bone but in the surrounding tissues. The speed of healing of fractures is usually in proportion to the amount of available circulation to and between the fragments. 2 In spite of the foregoing deduction, all the causes of delayed union and of non-union have not yet been determined. 3 The percentage of delayed union and non-union in fractures of the femur is not so great as in fractures of the tibia. 4 There are more cases of delayed union and non-union in the middle third of the tibia than in the upper and lower thirds. 5 The majority of [the author's] patients received some form of calcium therapy during their fracture treatment with little recognizable effect on the end result. 6 In the instructions to patients and students due consideration should be given to the slowness and uncertainty of the healing of fractures of the tibia and femur, so that patients may be prepared for the long period of time possibly necessary for the healing of these fractures. 7 The use of skeletal traction and the use of internal or external skeletal fixation in no way speeds the healing time of bone, and in some instances retards it because of distraction, infection, or the osteolytic effect of the metals used. 8 In the series of cases presented, circumstances in some instances necessitated the use of skeletal traction, plating, and external fixation (Havnes). In none did [the authors] feel that the results obtained by such methods were in any way superior to those of conservative treatment, when alignment could be maintained even at the expense of a loss of length or as much as three-quarters of an inch.

Malleolar Fractures—The increased interest in malleolar fractures and particularly in the advisability of internal fixation is shown by several articles on this subject. Muller⁴⁹⁵ ably describes the fracture of the internal malleolus which goes on to fibrous union or nonunion because of interposition of fibrous tissue between the fragment and the fracture bed as a result of incomplete or insecure reduction. He advises open reduction with fixation by a long vitallium or wood screw. This minimizes chance of fibrous union, maintains reduction and permits early active motion. This author advises motion as early as the second day.

[ED NOTE The method described is excellent and deserves more general acceptance, but this reviewer questions the advisability of such early motion, preferring to obtain wound healing for two weeks and then to use a walking cast for another two to four weeks, with unprotected weight bearing in four to six weeks.]

Fernandez⁴⁹⁶ reports a case of tibiofibular diastasis fixed by a long wood screw through the fibula and into the tibia. This is a disabling and often unrecognized deformity which leads to serious disability if overlooked.

[ED NOTE The method of fixation has been used by this reviewer with satisfaction.]

⁴⁹⁵ Muller G M Fractures of the Internal Malleolus Brit M J 2 320 (Sep. 8) 1945

⁴⁹⁶ Fernandez L L Diastasis tibio-peronea Tornillo de vitallio Prensa med argent 32 1709-1711 (Aug 31) 1945

Nystrom⁴⁹⁷ describes a method for reduction and fixation of the displaced posterior malleolar fracture. A carpenter's awl is inserted through the achilles tendon; the fragment is engaged, reduced and held in position by the awl while a vitalium nail is driven in for fixation. If the ankle is dislocated, it must be reduced first and then the procedure can be carried through a posterior window in the cast. It must be done promptly.

Perrigard⁴⁹⁸ discusses posterior dislocation of the ankle with malleolar fractures and describes a so-called jujitsu hold to facilitate reduction. The illustrations must be seen adequately to visualize the method. He emphasizes the importance of a properly fitted cast for an adequate period (three months).

Barnes⁴⁹⁹ discusses external malleolar fracture with some discussion of anatomy in reference to the various levels of fracture. He points out that treatment should be designed to (1) restore a proper weight-bearing line (2) restore normal articular relations and (3) obtain painless motion. The result depends on (1) anatomic reduction and fixation (2) normal tibiofibulotalar articulation and (3) restoration of muscle tone. He cites many errors commonly occurring in treatment of malleolar fractures and urges greater care and attention in this fracture.

Magnusson⁵⁰⁰ is writing a series of articles on late results in malleolar fractures, the present review covering one⁵⁰⁰ and part of another⁵⁰¹. The former concerns late results in the supination or inversion type of fracture treated nonoperatively. Supination fractures are described and the author states that 127 patients with this type of fracture were treated. Sixty-one of these patients came in for follow-up examination both clinical and roentgenologic. Treatment occurred during the period from 1931 to 1940. In the group of 61 patients, 24.6 per cent reported subjective symptoms, but all the patients were following their regular occupation. There were 4 cases of varus position, all belonging to the bimalleolar group, but no case of valgus position was observed. Widén.

497 Nystrom, G. Contribution to Treatment of Fracture of Posterior Border of Tibia by Malleolar Fractures. *Acta radiol.* 25: 672-678, 1944.

498 Perrigard, G. E. Reduction of Posterior Dislocation of Ankle Complicated by Fracture of Distal End of Tibia and Fibula. *Canad. M. A. J.* 52: 42-44 (Jan.) 1945.

499 Barnes, H. A. The External Malleolar Fracture. *U. S. Nav. M. J.* 44: 509-514 (March) 1945.

500 Magnusson, R. On the Late Results in Non-Operated Cases of Malleolar Fractures. Fractures by Supination Together with Some of the Late Results in Non-Operatively Treated Malleolar Fracture. *Acta chir. Scandinav.* 92: 259-277, 1945.

501 Magnusson, R. On the Late Results in Non-Operated Cases of Malleolar Fractures. Clinical-Roentgenologic Statistical Study. Fracture by Flexion, *Acta chir. Scandinav.* (supp. 84) 90: 1-176, 1944.

changes seemed to show age as a significant factor. In the 85 cases without deforming changes the average age of the patients at the time of accident was approximately 35 years, and at the time of after-examination, about 40.5 years. In the 104 cases with unilateral deforming changes, the average age at the time of accident was 43.9 years, and at the time of after-examination about 49.8 years. In the 22 cases with bilateral deforming changes the two age figures were 56.4 and 63.2 years.

Holstein⁵⁰² discusses fractures due to explosive effect of blast from below decks, citing the frequency of nerve or vascular changes. He stresses the importance of repeated paravertebral block in these cases.

Fractures in the Foot—Calcaneum Fractures. Harris⁵⁰³ and Poborsky⁵⁰⁴ in separate articles discuss various types of fractures of the calcaneum and present their favorite methods for reduction and fixation, both favoring multiple pins if displacement is severe.

Kjaer and Anthonsen⁵⁰⁵ in an extensive article report 27 calcaneum fractures with arthrodesis in the talocalcaneal joint and in Chopart's joint (triple arthrodesis) treated from 1936 to March 1941. Five patients were omitted from consideration in the article for various reasons (circulatory disturbances in 1 case and treatment too recent or incomplete at time of writing in 4 cases) leaving a total of 22 cases, with an average fracture age of 9.4 months. Operation was performed on account of protracted complete inability to work, pain in the foot and reduced mobility in the talocalcaneal joint. Prognosis was found to be particularly poor with conservative treatment. Some details of operative technique are given. After-treatment is as follows: At the end of four weeks, the padded plaster bandage is replaced by an unpadded walking cast for eight weeks, and then by a foot brace for four to twelve months. The authors question the value of the foot brace. No physical therapy was used beyond submarine massage on the days when the patient did not stand on his foot after removal of the last plaster bandage and before the foot splint or arch support had been made. The only complication found was an insignificant necrosis of the edges of the wound in 2 cases. Operative results were as follows: In all cases a bony ankylosis of the talocalcaneal joint was obtained, in 2 cases the ankylosis of Chopart's joint was only partial, but this did not impair the function of the foot. Clinical results as observed in March 1941, showed that 19 old fractures had been treated with arthrodesis and that the result was excellent in 10 cases and good in 5, there was improvement in 3 and no change in 1.

502 Holstein, A. Concussion Fractures and Dislocations of the Small Cranium. *U. S. Nav. M. Bull.* 44:790-792 (April) 1945.

503 Harris, R. I. Fractures of Os Calcis. Improved Methods of Treatment. *Bull. Vancouver M. A.* 21:43-47 (Nov.) 1944.

504 Poborsky, R. W. Calcaneum Fractures. *Indust. Med.* 13:591-2 (Dec.) 1944.

505 Kjaer, S. and Anthonsen, W. Calcaneum Fractures. Triple Arthrodesis. *Acta chir. Scandinav.* 87:191-213 1942.

In addition 3 recent fractures were treated, 2 with excellent results and ability to work at the end of six to eight months, and 1 with good result and ability to work four months after operation. Average age of the patient at the time of operation was 37 years (minimum 17 years maximum 55). Average period of preoperative disablement was 9.4 months. Postoperative disablement, including the period of treatment, in cases with excellent result (12), was approximately six months (minimum four, maximum twelve, and in cases with good result (6) approximately the same. In the cases with improvement (3) the period of disability was long (twenty-four, eight and twenty-five months), and 1 patient, whose condition was unchanged after operation, was still unable to work at the time of writing. The period of treatment was approximately one hundred days. Working capacity in relation to the age of the patient showed that there was no definite relation between the functional result and the age of the patient. The same was true of the period of postoperative disability. Mobility of the ankle was somewhat reduced in about half of the cases and greatly reduced in 3 cases. Muscular atrophy of the leg involved was noted in all patients to the extent of 1 to 2.5 cm.

Fatigue, Strain and March Fracture. Leveton⁵⁰⁶ reports 259 fatigue fractures in the metatarsals (by far the most common site) treated at one station hospital. His conclusions from this large group of cases are as follows:

1 Metatarsal march fracture is primarily an occupational disease of soldiers. 2 The author believes that metatarsal march fractures are caused by fatigue of the peroneus longus and tibialis posterior muscles. 3 March fractures are more properly termed fatigue fractures. There is no basis for the belief, as some authors have indicated, that metatarsal march fractures are due to spasm and overactivity of the interosseous muscles. 4 The presence of an atavistic foot as an etiological factor of metatarsal march fracture is greatly over-rated. 5 All of the metatarsal march fractures in this series occurred in soldiers with normal feet, or in cases of slight degree of pes planus and in cases of pes cavus. Not a single case of severe pes planus was encountered. 6 Pre-induction occupation of the soldier does not appear to be a decisive factor except so far as the tolerance of fatigue may be concerned. 7 The thinness of the metatarsal bone plays no important role in the etiology of metatarsal fractures. 8 In the 259 fractures all age groups from 18 to 38 were involved, but the 18 and 19 year old group were chiefly affected. 9 March fractures of the metatarsals involved all bones of the metatarsal segment but chiefly the second and third of the right foot. 10 Twenty-three cases of multiple metatarsal march fractures were encountered. 11 Fractures of the metatarsal bone involved 2.35 per cent of 10,953 cases seen by the orthopedic surgical section at the author's station hospital.

Scott⁵⁰⁷ reports 58 fatigue fractures from a Naval training center and advances the theory that a common predisposing cause is a thyroid defi-

⁵⁰⁶ Leveton, A. L. Metatarsal March (Fatigue) Fractures. *Am. J. Surg.* 70: 49-57 (Oct.) 1945.

⁵⁰⁷ Scott, W. March Fractures. *Surg. Gynec. & Obst.* 81: 525-529 (Nov.) 1945.

ciency Forty-eight of his 58 cases were studied metabolically. He recommends five to ten days of bed rest with thyroid if indicated. The patient is then returned to duty with enough thyroid for nineteen days. No other treatment is used.

Kitchin and Richmond⁵⁰⁸ report 2 fatigue fractures, 1 in the upper part of the tibia and 1 in the lower part of the femur. They point out that in certain stages such fractures may be confused with Ewings or osteogenic sarcoma.

[ED NOTE The reviewer recalls a case many years ago seen in consultation regarding a recommendation of amputation of the foot because of "osteogenic sarcoma" of the second metatarsal. Investigation revealed a typical march fracture.]

Wolfe and Robertson⁵⁰⁹ report 2 cases of stress fracture, 1 in the tibia and 1 in the femur. Both were diagnosed as a strain. The femoral fracture went on to complete fracture before the stress fracture was recognized.

Bingham⁵¹⁰ refers to 4 cases of stress fracture of the femoral neck reported by Henry and adds a case of intertrochanteric stress fracture with varus deformity.

Tortosa⁵¹¹ reports 3 cases of stress fracture, in 1 of these cases the fractures were bilateral ischiopubic, involving a most unusual location.

OPERATIVE FIXATION OF FRACTURES

A Medullary Nailing—In the past three years, there has been a great revival of interest in, or a rediscovery of the use of, intramedullary nails for the fixation of fractures of the long bones. Forty years ago, Lambotte used a longitudinal wire to immobilize fragments of the clavicle. In 1920 Groves inserted an axial nail in a comminuted fracture of the femur. In 1924, Lambotte used intramedullary pins in the femur, the humerus and the metacarpals. Danis, in 1937, used longitudinal wires in the bones of the forearm, as did L. V. and H. L. Rush in this country. In 1940 Lamberton used metal pins in the forearm and the femur and James Dickson reported similar experience. In recent textbooks, Bohler, Brumcroft and Murray, Soeur, Bonnin and Watson-Jones describe this method of fixation of certain fractures of long bones.

Since 1942 the v-shaped stainless steel nail devised by Kuntzler has been widely used in Europe and recent articles describe experience with

508 Kitchin, I. D. and Richmond, D. A. Two Unusual Stress Fractures. *Brit. M. J.* 2: 214-215 (Aug. 18) 1945.

509 Wolfe, H. R. I. and Robertson, J. M. Fatigue Fracture of Femur and Tibia. *Lancet* 2: 11-13 (July 7) 1945.

510 Bingham, J. A. W. Stress Fracture of Femoral Neck. *Lancet* 2: 13-14 (July 7) 1945.

511 Rovira Tortosa, A. Fracturas lentas o fracturas por sobrecarga con tribucion clinica. *Cir. d. ap. locom.* 1: 362-369 (Oct.) 1944.

"Kuntscher nails" The principles are essentially those which have been described many times before but much of the recent interest stems from the problems of comminuted gun-shot fractures of the most recent war

F Martin Lagos¹² reported the use of this method in 14 cases In the femur, the nail was introduced from the lower or the upper end In the humerus a slightly curved nail was used The author said that there is little danger of air embolism and that in cases of infection the nail serves as a drain

A W Fischer and R Maatz¹³ give a detailed report of their experience of medullary nailing in over 200 cases The more cases they did the more they saw need for special instruments to insert and to remove the nails and better protection of the hands from exposure to roentgen rays Also they found that many nails of many sizes were necessary to provide the optimum fixation It nails did not fit tightly in the medullary space there was danger of rotation of fragments, which necessitated the use of casts or splints Corrosion of the nails occurred in some of the early cases due to the use of improper metal Splitting of the bone, migration of the nail out of position breaking of the nail and late atrophy of the bone were some of the serious unfavorable results The article stresses the minute details of treatment from "time of operation" to "removal of nail" and is the best of the recent reports on this subject

H Griessmann and H Reich¹⁴ performed experiments on animals to compare the healing callus of fractures treated by plaster casts with those treated by medullary nails When nails were used, the callus extended for a greater distance on each side of the fracture site than when casts were used The callus following medullary nailing was of "higher structural value" than that seen after fixation by plaster cast After medullary nailing the forces of traction and rubbing were eliminated and only pressure force remained This, the authors felt was more conducive to the development of strong solid union

[ED NOTE All this may be so, but the shearing force possible when the fragments rotate slightly about the nail is much more injurious to callus than traction]

The insertion of medullary nails when fragments are displaced is far from easy, and K Herzog¹⁵ has described a linked metal tube to be used to lever the fragments into position Two metal sleeves are

512 Martin Lagos, F El enclavamiento medular de Küntscher Rev españ cir traumatol y ortop **1** 1-18 (July) 1944

513 Fischer A W and Maatz R Weitere Erfahrungen mit der Marknagelung nach Küntscher, Arch f klin Chir **203** 531 1942

514 Griessmann, H, and Reich, H Vergleichende Untersuchungen über den Ablauf der Knochenbruchheilung bei der Marknagelung und bei den mit Gipsverband behandelten Frakturen Arch f klin Chir **205** 455 1944

515 Herzog, K Verbessertes eigenes Hebelgerät zum Ausgleich der Seitenverschiebung bei Brüchen der langen Röhrenknochen zur Anwendung bei der Marknagelung, Zentralbl f Chir **70** 1656 (Nov 13) 1943

maneuvered over the fragments to aline them before the nail is inserted. The article contains five drawings to illustrate the device and three roentgenograms to demonstrate its use.

Because it is necessary that medullary nails fit tightly into the bone, R Maatz⁵¹⁶ has developed a wedge-shaped piece of metal which is driven in between two flat nails that are previously inserted. The wedge has "stepped" edges which engage the substantia spongiosa to prevent slipping.

[ED NOTE This seems to be making an easy operation difficult, and the fact that three nail heads protrude from the wound would tend to increase the chance of infection.]

A Vogl⁵¹⁷ reports 7 cases in which medullary nailing was used in comminuted gunshot fractures and in pseudarthroses of fractures of long bones.

[ED NOTE His roentgenograms show good union, but others have found this method useless in the repair of ununited fractures.]

In C Rocher's experience⁵¹⁸ with 43 cases of medullary nailing there were three points emphasized: the need for a large assortment of nails to insure the right nail for the right case, the difficulty of securing nails of the proper quality of metal and the great difficulties of removing the nails after the fractures had healed. The author, however, was enthusiastic about this method of treatment of fractures and felt that it was "the method of osteosynthesis of the future."

M Garcia Portela⁵¹⁹ discusses all the background of Küntscher nailing and reviews 457 cases found in the literature. His 10 personal cases include 3 corrective osteotomies (2 of the femur, 1 of the ulna) of old fractures where intramedullary nails were satisfactory devices for postoperative fixation.

L Sierra Cano and E Rodriguez Valdes⁵²⁰ report the use of medullary nails in 13 cases including fresh fractures, pathologic fractures, compound fractures and ununited fractures.

W Heim⁵²¹ points out several disadvantages of intramedullary nailing. It is difficult to place the patient in proper position for reduc-

516 Maatz R. Ueber Formschlüssigkeit bei der Küntscher-Nagelung. Zentralbl f Chir 70 1641 (Nov 13) 1943

517 Vogl, A. Die Marknagelung in der Wiederherstellungschirurgie. Zentralbl f Chir 70 1649 (Nov 13) 1943

518 Rocher, C. L'enclouage centro-medullaire des os longs, Presse med 53 94-95 (Feb 24) 1945

519 Garcia Portela, M. El enclavamiento medular de Küntscher, Rev cln españ 15 1-18 (Oct. 15) 1944

520 Sierra Cano, L. and Rodriguez Valdes E. Los problemas mecanicos y biologicos del enclavamiento medular de Küntscher, Cir d ap locom 2 193-220 (Jul) 1945

521 Heim W. Ergebnisse aus der Nagelungsbehandlung bestimmter Fracturenbrüche, Deutsche med Wchnschr 70 491 (Sept 1) 524 (Sept 15) 1944

tion of the tracture and insertion of the guide wire. Incorrect introduction of the nail is easy, and replacement of the fragments is often difficult. Nails must be chosen exactly for proper length, thickness and shape in the case of each tracture. Insertion of nails that are too thick may break the bone, and extraction of the nails may also endanger the bone. The author concludes with a detailed analysis of his 23 cases and states that "the surgeon must be very selective in his procedure in the individual case."

Under unfavorable war conditions B. M. Tordoir and E. J. Moeyss²² used intramedullary nails in 21 cases of closed tractures and 10 cases of compound fractures. While they felt that intramedullary nails were best adapted to transverse fractures of the shaft, they also applied the method to spiral and comminuted fractures. They were of the opinion that this method promised hope in the immobilization of compound fractures.

It is too early to predict the future for intramedullary nailing, and sufficient experience has not yet been gained. Nevertheless, the method holds promise in certain comminuted fractures where there are several long fragments that cannot be immobilized by the usual methods of treatment. It may also prove superior to some forms of plating operations when the latter require too much stripping of periosteum from the site of the tracture.

B. Devices for External Fixation—The names of Lambotte, Haynes, Anderson, Stader and many others have been identified with apparatus which was designed to immobilize fractures without introducing permanent metal plates and screws into the bone. The impelling motives in each case were to try to avoid infection, to provide early articular motion and to eliminate "electrolytic osteitis" from plates and screws. How successfully these aims have been achieved is still open to question.

C. F. Ferciot²³ cites the disadvantages of external fixation: the need for special apparatus, the special skill required for insertion of pins, additional damage to soft tissues, the temptation to keep improving the position and irritation of the soft tissue about the pins. The advantages of the method are: accurate reduction with minimal trauma, maintenance of reduction, ease of care of soft tissues and possibility of early articular motion. In 22 of his 48 cases, in young adults, good bony union was secured, though the healing time was not materially affected. Although early weight bearing was not encouraged, articular motion shortened the convalescence and minimized atrophy of the muscles.

²² Tordoir B. M. and Moeyss E. J. Treatment of Certain Types of Fractures with V2A Steel Nail in Medullary Cavity (Küntscher Method) J. A. M. A. 128 792-794 (July 14) 1945

²³ Ferciot C. F. The Use and Abuse of External Skeletal Fixation Nebraska M. J. 30 55-57 (Feb.) 1945

E Marques Porto⁵²⁴ considers the Roger Anderson method of treating fractures of the shaft of the femur a notable advance

A more detailed study by I E Siris⁵²⁵ leads to the conclusion that "in 80 cases of external mechanical pin fixation of fractures, the high incidence of discharge from the pin sites (46 per cent), of osteomyelitis of the pin sites with persistence of discharge long after the fracture had united (22.5 per cent), and of deaths (10 per cent) should preclude the further use of the method as a routine procedure for fractures of the long bones" The author feels, furthermore, that much emphasis has been laid on ambulation and articular motion and that these features should not be the motivating factors for the use of external mechanical pin fixation

[ED NOTE These condemnatory opinions are of much value, since they are expressed by one who has had a large experience with external fixation]

In England, E H Wilson⁵²⁶ noted that patients who sustained fractures of the femur were disabled more than a year and always suffered some degree of limitation of motion of the knee joint The 350 patients treated at the American Hospital in Britain by external fixation were generally much better than the ones treated in the Army Still the advantages and disadvantages of external fixation tended to neutralize each other except when treatment was well supervised by trained personnel

For the protection of projecting pins in the bone, H D Caylor and L Witwer⁵²⁷ have described fiber collars with set screws which can be attached over the pins and thus cover the sharp ends

[ED NOTE This is one way of overcoming the tendency for pins to move back and forth in the bone and thereby to spread infection]

C Devices for Internal Fixation—The use of metallic internal fixation in fresh fractures continues to arouse interest even after three decades of discussion on the subject Nowadays the articles tend more to descriptions of technical details or of newly developed metals rather than to questions of the advisability of open reduction

524 Marques Porto, E Novo metodo de tratamento ambulatorio das fraturas Rev med cir do Brasil 52 679-685 (Sept-Oct) 1944

525 Siris, I E External Pin Transfixion of Fractures. Analysis of Eight Cases Ann Surg 120 911-942 (Dec) 1944

526 Wilson E H Functional Treatment of Fractures and Other Injuries Arch Phys Med 26 349-352 (June) 1945

527 Caylor, H D, and Witwer L Device to Protect the Projecting Fracture Kirschner Wires Steinmann Pin or External Fixation Pins Am J Surg 70 1 (Oct) 1945

In Russia V V Troitskiy and D N Tsitrin⁵²⁸ prepared an alloy of magnesium with a small amount of cadmium to increase solidity. Plates, screws, clamps and nails of this metal were placed in animals where they slowly dissolved without altering the blood levels of magnesium.

[Ed. Note: Magnesium alloys have been utilized many times previously and are supposed to possess the virtue of slowly dissolving in the body. The great drawback is that surrounding bone is "dissolved" at the same time.]

D B Cobb⁵²⁹ places oblique Kirschner wires across fractured long bones and incorporates the projecting ends in the cast. He feels that this causes less disturbance of the periosteum than any other method of fixation.

C S Venable⁵³⁰ emphasizes that after plates have been placed on long bones the fragments are more securely anchored if a long transfixion screw is placed obliquely across the line of fracture.

In a general discussion on fixation of fractures Dr Cubbins⁵³¹ emphasized that fractures of the hip must be perfectly reduced and firmly secured to obtain satisfactory results. Dr Lewin could see no advantage in unpadded casts or reason to change from "properly padded, properly applied casts to the unpadded ones." In considering the treatment of fractures of the humerus, Dr Lewin characterized the hanging cast as "a gift from heaven."

A L Murphy⁵³² gives a brief review of the history of internal fixation and states that there is a swing to more open reductions. He thinks that better understanding of the need for prevention of muscle atrophy is responsible for this. Also the introduction of vitallium has made available a material which is better tolerated by the tissues than any of the other new agents for internal fixation.

The details of technic of applying plates to bones is well outlined by W F Lyon⁵³³. His most significant point is the emphasis on need for exact centering of the screws in the holes in the plate.

528 Troitskiy V V, and Tsitrin D N. Absorbable Metallic Alloy "Osteosintezit" as Material for Fixation of Fractured Bones. *Khirurgiya* 1944 no 8 pp 41-44.

529 Cobb, D B. A Simple Method of Fracture Fixation with the Kirschner Wire. *North Carolina M J* 6 92-96 (Feb) 1945.

530 Venable, C S. The Use of Transfixion Screws, *Am J Surg* 67 145-154 (Feb) 1945.

531 Slobe, F W, Lewin, P, Cubbins, W R, Diehr A H, and Wellmerling H W. Fixation of Fractures. Panel Discussion, *Indust. Med* 14 120 (Feb) 1945.

532 Murphy, A L. The Present Status of the Internal Fixation of Fractures, *Canad M A J* 52 582-587 (June) 1945.

533 Lyon W F. Technic of Plating Long Bone Fractures, *S Clin North America* 25 99-110 (Feb) 1945.

[ED NOTE Dr Lyon has been interested a long time in the question of holding power of screws in bone, and his opinions on this subject are backed by much authority]

Ulises Sosa de Quesada and Luis Saiz Navarro⁵³⁴ describe various methods of treatment of 96 fractures of the shaft Their results were best in those cases in which treatment was with vitallium plates and screws

Gerard Saint-Onge⁵³⁵ recommends suturing of bones with silk-worm gut or bronze wire because of "war shortage of materials"

[ED NOTE War shortage is about the only justification for bone sutures This method was abandoned many years ago because it did not provide sufficiently secure fixation]

R M Yergason⁵³⁶ advises placing Kirschner wires obliquely across fractures while leaving the ends projecting through the skin For fractures of the patella and the olecranon he prefers heavy silver wire He also discusses the relative merits of vitallium, tantalum and stainless steel

FRACTURES OF THE SPINE AND THE PELVIS

War wounds of the pelvis are described by L G Lewis,⁵³⁷ and he cites the types of treatment needed when urethra, bladder and rectum are injured Suprapubic cystotomy and colostomy are performed early, hemostasis is essential as well as repair of visceral defects Early drainage of the bladder to prevent extravasation is probably the most important life-saving measure in these cases

Walter Carruthers,⁵³⁸ who has written much on fractures of the pelvis, states that in 16 per cent of cases of fracture of the pelvis there is accompanying injury to soft tissue In 10 per cent there are injuries to the urinary tract He feels that fragments must be perfectly restored in women to prevent interference with child bearing In his experience with 66 cases, he has been able to effect excellent reduction with the turnbuckle casts for traction and lateral separation of the thighs

Another discussion of the turnbuckle cast treatment for fractures of the pelvis, by C M Silver and H W Rusbridge,⁵³⁹ concerns its

534 Sosa de Quesada, U, and Saiz Navarro, L. Concepto actual en el tratamiento de las fracturas diafisarias de los huesos largos, *Cir ortop y traumatol Habana* 12 3-23 (Jan-March) 1945

535 Saint-Onge G. Procède simplifié d'ostéo-synthèse, *Union méd du Canada* 74 599 604 (May) 1945

536 Yergason, R. M. Metallic Fixation of Fractures by Use of More Recent Methods and Appliances *Connecticut M J* 9 276-280 (April) 1945

537 Lewis, L G. Cases of Severe Pelvic Injury. *Tr South S A* (1944) 56 86-93 1945

538 Carruthers W. Anatomic and Functional Reductions of Fractures of the Pelvis *Am J Surg* 69 39-46 (July) 1945

539 Silver C M and Rusbridge H W. A Treatment for Displaced Fractures of the Pelvis, *J Bone & Joint Surg* 27 154-156 (Jan) 1945

use in the Army in North Africa. With makeshift web straps enough tension could be obtained to reduce overriding fragments perfectly.

In 45 per cent of pelvic ring fracture J. G. Bonnin⁴ found evidence of fractures of the sacrum. Most of these involved the upper lumbar with symptoms referable to the first and second sacral nerves—tingling over the outer side of the foot, weakness of the hamstrings and muscles of the calf and diminution of ankle jerk. Recovery was slow and some impairment of gait persisted in a number of cases.

S. N. Deboo⁵¹ says that fluoroscopy is inaccurate in making diagnostic studies of injured backs. Even good roentgenograms are sometimes misinterpreted because of persistent epiphyses or partial ossifications of the anterior longitudinal ligament that may be confused with true fractures.

A special sprain fracture of the spine is described by J. H. Annan⁵² in British prisoners of war who were used by the Germans to shovel sand. Fifteen cases of "shovelers' fractures" were observed wherein the sixth and seventh cervical spinous processes were fractured spontaneously after heavy labor. Undernutrition and excessive fatigue were probably contributing factors. Recovery was complete after conservative rest therapy.

Fractures of the spine in "metrazol shock," according to Alberto Fernandez Saralegui⁵³ are really avulsion fractures. Preliminary spinal anesthesia, as recommended by Hamra and Bennett is advisable to prevent the severe strains on the spine.

A new type of corset for the treatment of spinal fractures has been developed by G. Sajgo⁵⁴. The ordinary body cast is used six weeks to "rest the spastic musculature of the back." Then a corset is applied which is hinged in the middle to allow gradual correction while at the same time permitting light treatments and massage.

The nursing care of patients with fractures of the spine and injury of the cord is explained by L. A. Mount⁵⁵. She emphasizes the irreparable harm which can be done patients by improper handling and points out the advantages of skeletal traction on the skull. Prevention of

540 Bonnin, J. G. Sacral Fractures and Injuries to the Cauda Equina. *J. Bone & Joint Surg.* **27** 113-127 (Jan.) 1945.

541 Deboo, S. N. Radiological Aspect of Fractures of the Spine Based on an Analysis of Two Hundred and Fifty-Four Cases of Injury to the Back. *M. Bull., Bombay* **12** 353-357 (Dec. 16) 1944.

542 Annan, J. H. Shovelers' Fracture. *Lancet* **1** 174-176 (Feb. 10) 1945.

543 Fernandez Saralegui, A. Fracturas por shock cardiazolico. *Rev. Asoc. med. argent.* **58** 864 (Oct. 15) 1944.

544 Sajgo, G. Ein neuer Typ von Redressement- und Entlastungs-mieder, *Ztschr. f. Orthop.* **74** 309, 1943.

545 Mount, L. A. Injuries of the Spinal Cord. Treatment of Injuries Associated with Fractures of the Spine. *Am. J. Nursing* **45** 101-103 (Feb.) 1945.

bedsores and supervision of bowel and bladder function are likewise well presented

A new adjustable cervical spinal brace is described by Edwin Boldrey.⁵⁴⁶ Since plaster of paris casts are bulky and uncomfortable and are not particularly effective, this brace seems to offer more enduring support to the neck. An aluminum cup is shaped about the occiput and as far forward as the ears. This is attached to the shoulder and trunk portion of the brace by a ball and socket joint. Since no apparatus fits under the chin, the mandible is free, and this permits chewing and talking without effort. When properly fitted to the patient, this brace holds the head securely and yet does not cause any distressing discomfort.

The operative treatment of dislocations of the cervical part of the spine is discussed by R. J. B. McEwen and J. G. Bickerton.⁵⁴⁷ In 3 cases in military hospitals, the dislocated facets were exposed and levered into position by direct pressure. Traction by skeletal tongs in the skull was maintained during the operation to prevent injury to the spinal cord. Afterward plaster casts were applied to be worn during convalescence.

[ED NOTE: Rogers and others have shown that there is a great tendency to recurrence of dislocations of the cervical part of the spine even after they have been well reduced. Consequently they advised wiring the spinous processes at the time of the operation or inserting a bone graft.]

From the Mayo Clinic J. J. Hinchey and W. H. Bickel⁵⁴⁸ reported 8 cases of fracture of the atlas. While this is a serious injury, it is fatal in only 10 per cent of cases. Often there is fracture of the skull or of the cervical part of the spine in addition. The anatomic features of the atlas are well explained in relation to the mechanism of the fracture, since there are few clearcut symptoms. Treatment is by head traction followed by the use of a plaster collar for six or eight weeks. Stiffness of the neck and occipital neuralgia are uncomfortable after-effects of this injury.

E. H. T. Hambly⁵⁴⁹ has similarly shown that fractures of the odontoid process of the axis are not so deadly as was once supposed. There may be simple cracks at the base of the odontoid process, fractures of the odontoid with dislocation of the axis, or hyperextension fracture dislocations of both axis and atlas. The author reports a case of fracture

546 Boldrey, E. Supportive Immobilization of the Cervical Spine. *Surg Gynec & Obst* 80:107-108 (Jan) 1945

547 McEwen, R. J. B. and Bickerton, J. G. Dislocations of the Cervical Spine Treated by Open Reduction. *J Bone & Joint Surg* 27:679-682 (Oct) 1945

548 Hinchey, J. J. and Bickel, W. H. Fracture of Atlas. *Ann Surg* 121:826-832 (June) 1945

549 Hambly, E. H. T. Fracture of the Odontoid Process. *Med J* 1944
Fixation. *Lancet* 2:851 (Dec 30) 1944

dislocation of the odontoid with paralysis which was successfully treated by traction and manipulation under anesthesia

TRACTION COMPLICATIONS INJURIES TO NERVES

Peripheral nerve injuries with fractures are enumerated by E S Gurdjian and H M Smathers.⁵⁵⁰ Their study is based on 53 cases injuries to a radial nerve 32 cases to an ulnar nerve 9 cases to a median nerve 3, to a peroneal nerve 8 and to a sciatic nerve 1. Early exploration of injured nerves is recommended especially if the fractured bone is to be treated by open reduction. When the ulnar nerve is injured with fracture of the medial condyle of the humerus the authors recommend prompt exploration and anterior transposition of the nerve. In compound fractures, it is now possible to do primary repair of nerves because of modern chemotherapeutic methods. The article possesses an excellent bibliography.

The importance of early treatment of nerve injuries is stressed by R G Spurling,⁵⁵¹ who was consultant in North Africa. Early in the European War, patients with injuries to bones and nerves were treated first for the fractures and then two to four months later were referred to the neurosurgeons for repair of the nerves. After such an interval only 20 per cent of the cases had satisfactory outcome. In December 1944 a program was instituted for early treatment of injuries to nerves and 300 patients were treated within six weeks after the accident. The results were much better, especially in the case of sutures of radial and sciatic nerves. The poorest results were obtained in sutures of the brachial plexus, the median and the ulnar nerve, because of the mixed nature (motor and sensory) of these nerves.

COMPOUND FRACTURES

The National Research Council's Project on Contaminated Wounds, reported by F L Meleney and A O Whipple,⁵⁵² summarized the results of treating 926 wounds involving soft tissue, 674 compound fractures and 591 burns, a total of 2,191 injuries treated at six centers throughout the United States over a twenty-two month period. The chief factors concerned with the development of infection in soft tissue wounds and compound fractures were found to be (1) degree and extent of damage to

550 Gurdjian, E S, and Smathers, H M. Peripheral Nerve Injury in Fractures and Dislocations of Long Bones, *J Neurosurg* 2 202-219 (May) 1945

551 Spurling R G. Early Treatment of Combined Bone and Nerve Lesions. *Bull U S Army Med Dept* 4 444-446 (Oct) 1945

552 Meleney F L and Whipple A O. Statistical Analysis of Study of Prevention of Infection in Soft Part Wounds Compound Fractures and Burns with Special Reference to Sulfonamides. *Surg Gynec & Obst* 80 263-296 (March) 1945

soft tissue, (2) degree of gross contamination by foreign material (3) duration of time between injury and surgical care, (4) nature of bacterial flora in wounds and (5) care and thoroughness with which devitalized tissue foreign bodies and gross contamination are removed. The first four of these factors applied in burns yet most important was the extent and depth of the burn.

The prophylactic use of sulfonamide compounds, locally or systemically or in combination, failed to reduce the incidence or severity of local infections in wounds or burns. The development of infection was not delayed, nor were pathogenic organisms eliminated from the wounds by the use of sulfonamide drugs. Sulfonamide compounds did minimize the spread of local infection, thereby reducing septicemia and death, however, this was accomplished by systemic drug therapy when infection developed in the controls as readily as when the drug was used prophylactically.

Although the results were somewhat disappointing, so far as the workers had hoped to find something which would prevent infection in these wounds, their observations indicated that the prevention of infection in both civilian and war wounds rests on the well known surgical principles of removal of devitalized tissue and contaminants with rapid restoration of normal functioning of the involved part. Such factors are beyond the scope of sulfonamide drugs.

A number of articles on the management of compound fractures and other war wounds appeared in 1945, depicting a pronounced evolution in the management of these cases. M. Sulamäa⁵³³ discussed the advantages of the Orr method and its counterpart, the Lohr method, used in 75 war fractures with a mortality of 5.3 per cent and one amputation. He stressed the importance of careful examination for other wound especially vascular injuries, before application of the closed plaster cast and warned against the possibility of the formation of abscesses beneath the closed plaster. He acknowledges the objection of the offensive odor and recommends that the closed plaster be discontinued in the late stage unless absolutely necessary.

Numerous articles during 1945 described the advent of delayed closure of war fractures and the use of penicillin as an adjunct to treatment. R. W. Hendry, W. C. Gledhill and B. H. Price⁵³⁴ reported their results in the management of 465 soft tissue wounds and 128 open fractures with local and systemic administration of penicillin, followed by secondary closures of these wounds, the result was 87 per cent closure.

533 Sulamäa M. Combination of Ointment Dressing and Closed Treatment of Gunshot Fractures. *Acta chir. Scandinav.* 89:483-492, 1944.

534 Hendry R. W., Gledhill W. C. and Price B. H. Treatment of Civilian Casualties. Two Stage Operation. *Lancet* 1:618-621 (May 19) 1945.

in compound fractures at the end of six weeks. They feel that the local instillation of penicillin in the site of the fracture is of value.

F H Bentley and others⁵⁵⁵ reported a series of 62 compound fractures treated by secondary closure (on the sixth day, on the average) combined with penicillin therapy. This method was successful in 58 cases with primary union of soft tissue and bone and in 2 other cases in which a second operation for removal of a foreign body was followed by union. In half of the 62 cases there was only local administration of penicillin and in the remainder there was a combination of local and systemic administration of penicillin without appreciable difference in the success of healing in the two groups. Bentley and his co-workers stress the importance of surgical therapy when combined with penicillin, especially the removal of foreign bodies and complete cutaneous closures.

E A MacNaughton⁵⁵⁶ reports the use of early secondary closure in the management of 10 compound fractures of the femur received during the Normandy invasion. He stresses the importance of (1) pre-operative preparation of the patient consisting of rest, transfusions, administration of penicillin and sulfonamide drugs and noninspection of the wounds, (2) early reduction of the fracture, (3) early and complete closure of the wounds based on clinical appearance of the wound rather than on bacteriologic survey and (4) maintenance of reduction and fixation in plaster of paris spica.

J A MacFarlane⁵⁵⁷ comments on the change in management of war fractures during the past five years from the closed plaster methods of Trueta to delayed closure of wounds in 90 per cent of all compound fractures with saving of life and limb and shortening the period of hospitalization. He points out that in an unpublished report from Italy equal success was obtained in two groups, one receiving prophylactic doses of penicillin and the other either inadequate amounts or no penicillin. MacFarlane credits much to the mobile surgery and shock teams and feels that, although penicillin plays its important part, the role of good surgical treatment cannot be overlooked.

[ED NOTE: The good results obtained in this type of war wounds were due chiefly to the use of good surgical judgment and the generally excellent type of surgical skill displayed in their management.]

The controversial subject of excision of wounds and resection of joints in managing war fractures was presented in several papers mainly

555 Bentley, F H, and others. Treatment of Compound Fractures by Early Wound Suture and Penicillin, *Lancet* 1 232-236 (Feb 24) 1945

556 MacNaughton, E A. Early Wound Closure and Treatment in Plaster of Ten Compound Fractures of Femur from Normandy Front, *J. Canad. M. Serv.* 2 237-247 (March) 1945

557 MacFarlane, J A. Compound Fractures in War, 1944, *Lancet* 1 135-138 (Feb 3) 1945

by Russian surgeons S O Portugalov⁵⁵⁸ recommended removal of all infected bone including the joints involved close to the limit of sound tissue, thereby saving the uninvolved distal portion of the limb. By resection the infection is removed, and the defect in the bone can be restored later by bone grafts. The author considered the resulting extremities following excision of joints and repair much better than the best prostheses.

Another Russian S R Mirotvortsev⁵⁵⁹ recommends conservative expectant treatment in wounds involving joint and synovial membrane. With failure of conservative measures he recommends wide arthrotomy and recommends resection of the joint if the pathologic process progresses. Immobilization in unpadded plaster casts is recommended routinely.

In a compact article on the treatment, prognosis and end results of managing war fractures O Wustmann⁵⁶⁰ warns against resection of joints for empyema, which is "always managed by operative drainage of the joint."

H von Haberer⁵⁶¹ from personal experience gained in World Wars I and II states that he is in favor of resection of joints in selected cases but at various times has opposed this practice. He considers resection of an infected joint unquestionably indicated in cases in which the infection constitutes danger to life should there be reason to believe that a halfway useful extremity will be the result. If the resection needs be so extensive that the extremity loses its functioning capacity, the author feels that amputation is preferable especially in the lower extremity.

[ED NOTE: Resection of wounds and joints is not considered a procedure of choice in the United States.]

H E Branch⁵⁶² states that bullet fractures of the long bone require more careful treatment than any other serious fracture. His article stresses conservation in debridement and management of these fractures and points out that fragments attached to periosteum and soft tissues act as "struts" or live bone grafts for the restoration of the shaft of the

558 Portugalov S O. Conservative Operations on Extremities Instead of Amputations and Exarticulations. *New Principle of Surgical Therapy of Septicopurulent Fractures*. Khirurgiya 1944, no 11, pp 64-70.

559 Mirotvortsev S R. Clinical Aspects and Therapy of Gunshot Wounds of Large Joints. *Soviet med* (no 7-8) 8:8-10 1944.

560 Wustmann O. Schussbrüche der Gliedmassen, *Deutsche med Wchnschr* 70:243 (April 28) 1944.

561 von Haberer H. Zur Frage der Gelenkresektion nach Schussverletzungen. *Chirurg* 15:729 (Dec 15) 1943.

562 Branch, H E. Bullet Fractures of Long Bones. *J Bone & Joint Surg* 27:227-232 (April) 1945.

bone Removal of readily accessible nonmetallic foreign bodies is urged but too extensive searching may do more harm than good

O Mayr⁵⁶³ calls attention to the fact that war fractures often heal in poor position and recommends the wedging of casts to correct angulation and restore proper alignment of the fragments

W F Stanek and W C Peterson⁵⁶⁴ warn against comparison of results in treating civilian type compound fractures and war fractures because of the difference in surrounding circumstances They stress the importance of reestablishment of articular motion and recommend the cooperation of orthopedic surgeons plastic surgeons and neurosurgeons at special centers for best results in compound fractures

An extensive article on the treatment of gunshot fractures was published by Oscar Hampton⁵⁶⁵ consultant in North Africa Under war conditions statistical studies were impossible though there were few infections and no serious sequelae from surgical treatment overseas Reductions were more accurate than might be expected because inadequate reductions were not tolerated Internal fixation of fractures with vitallium plates was performed when necessary to hasten recovery of articular motion Elaborate care of wounds led to a high proportion of primary unions in cases in which sutures were done immediately

M Cleveland and J A Grove⁵⁶⁶ discuss closure of compound wounds on the basis of their experience with 2393 cases "Delayed primary closure" caused 93 per cent to heal before the patients left the hospital Success of this operation depended on early and adequate debridement of the wound, rapid evacuation of the wounded to permanent rear medical installations, the use of penicillin and sulfonamide drugs and transfusions of whole blood

A general review of war wounds was given by P D Wilson⁵⁶⁷ He stated that improved treatment of shock with plasma and whole blood was most valuable in preparation for surgical treatment There was a swing away from the Orr technic of using no dressings and earlier closure of wounds became the rule Loss of bone was repaired by bone grafts fastened with vitallium screws

563 Mayr, O Einfache unblutige Korrektur schlecht stehender Frakturen im Kriege München med Wchnschr 90 571 (Oct 8) 1943

564 Stanek W F and Peterson, W C Compound Fractures Occurring in the Army Factors Influencing Treatment Am J Surg 67 333-341 (Feb) 1945

565 Hampton, O P Jr Reparative Surgery of Compound Battle Fractures in the Mediterranean Theater of Operations Ann Surg 122 289-332 (Sept) 1945

566 Cleveland M, and Grove, J A Delayed Primary Closure of Wounds with Compound Fractures J Bone & Joint Surg 27 452-456 (July) 1945

567 Wilson, P D Treatment of War Injuries of the Skeletal System Am Rev Soviet Med 2 395-406 (June) 1945

An interesting study of the effects of sulfonamide drugs in compound fractures was reported by M J Wilson and A R Cantwell⁶³ In 123 cases in which sulfonamide drugs were not used there were nine infections In 56 cases in which there was oral and local administration of sulfonamide drugs, there were six infections In other words, the first group showed less infection Consequently, "thorough surgical debridement and mechanical cleansing of the wound followed by complete rest of the devitalized tissue is still of primary importance"

SPECIAL FRACTURES

Orthopedic surgeons are frequently confronted with the problem of patients with "snapping jaws" Injection of sclerosing solutions into the joints has not been satisfactory, and neither has excision of the floating cartilage H N G Hudson⁶⁴ has described an operation which seems to offer some hopeful promise The temporomandibular joint is exposed by a curved incision and the capsule is cut by a vertical incision The cut edges are then overlapped and sutured together Also a pleat is taken in the capsule at the base of the zygomatic process The patients can open the mouth without "clicking," but there is a persistent tendency for the point of the jaw to deviate toward the side operated on whenever the mouth is opened widely

A statistical study of the fractures which occurred in the Richmond, Calif, shipyards in two and a half years was made by C C Cutting, L D Fisher and N Neadoff⁶⁵ One third of all the fractures occurred in the hands (metacarpals and phalanges) and more than one fourth occurred in the feet (metatarsals and phalanges) The sternum and the ribs accounted for 57 per cent of the fractures, fractures of the leg occurred in 24 per cent of cases and fractures of the spine in 24 per cent of cases

[Ed NOTE Fractures of the hands and the feet are common in most heavy manufacturing industries, but it is surprising how few fractures of the major long bones occurred in this series Undoubtedly modern safety measures are truly effective, especially since the Liberty ships built at Richmond were fabricated by unskilled emergency labor]

Athletic injuries are likewise on the decrease, as attested by W A Hanson and G W Hauser⁶⁶ In a study of 300 football

568 Wilson, M J, and Cantwell A R The Prevention of Infection in the Treatment of Compound Fractures, Bull New York M Coll, Flower & Fifth Ave Hosps 8 18-20 (April-June) 1945

569 Hudson, H N G Operation for Recurrent Subluxation of the Temporomandibular Joint, Brit M J 2 354 (Sept 15) 1945

570 Cutting, C C Fisher L D and Neadoff, N Survey of Over 13,000 Fractures in Employees of Richmond Shipyards California & West Med 63 216-218 (Nov) 1945

571 Hanson, W A, and Hauser, G W Common Injuries Associated with Football at the University of Minnesota Minnesota Med 28 755-758 (Sept) 1945

players at the University of Minnesota during the period from 1942 to 1945, there were no serious cranial or abdominal injuries. There were 2 cases of minor acromioclavicular separations, 2 instances of fractured ribs and 1 fracture separation of the seventh costal cartilage. There was 1 case of fracture of lumbar transverse processes. One dislocation of the elbow occurred, and there were 3 fractures of the carpal scaphoid, 8 fractures of the bones of the hand, 2 fractures of the tibia and 1 fracture of the nose. No serious accidents occurred to the ankles because they were well strapped before games, but there was an increase in injuries to the knee probably because the ankles were so well protected that the knees became the point of maximal strain.

Another special group of fractures following parachute jumps was described by P. A. Knepper.⁵⁷² Casualties were as high as 10 per cent when training began, but as more effective precautions were taken this casualty rate was reduced to less than 1 per cent. There were 7 compression fractures of vertebrae, 6 skull fractures, 79 fractures of the lower extremity and 50 fractures in other parts of the body. The fractures in the lower extremity are easy to explain on the basis of difficulties in landing.

HEALING OF FRACTURES

A method of determining healing by sound conduction is described by J. L. Weissberg.⁵⁷³ A tuning fork of 128, 256 or 512 frequency is placed against a bony prominence distal to the fracture and a stethoscope is placed on a bony prominence proximally. Comparison with sound transmission on the unfractured side yields evidence of the progress of healing and can be computed on a rough percentage basis. The author states that this is especially useful in the femur.

Metabolic changes in patients with fractures were studied by J. E. Howard.⁵⁷⁴ After fractures, healthy vigorous males suffer large losses of protein from the body which are not due to faulty absorption, the mechanical effects of immobilization or inadequate intake of vitamins. Rather there seems to be a disturbance in the normal exchange of nitrogenous constituents between the cells and their external environment. The large retention of potassium after such injuries may have some relation to physical fitness and the rate of recovery. Already debilitated patients do not show similar losses of nitrogen after fractures. It seems that during the first two weeks after the accident

⁵⁷² Knepper, P. A. Parachute Fractures, Surg., Gynec. & Obst. 81 53-55 (July) 1945

⁵⁷³ Weissberg, J. L. Evaluation of Bone-Continuity by Sound Conduction Bull. U. S. Army M. Dept. 4 471-474 (Oct.) 1945

⁵⁷⁴ Howard, J. E. Metabolic Observations on Convalescent Patients from Fractures, Tr. A. Am. Physicians 58 162-170, 1944

forced feeding of nitrogenous foods is not essential to recovery and might conceivably be harmful

J Roche and Mme R Martin-Poggi⁵⁷⁵ studied healing fractures in guinea pigs and found that two chemical substances operate at two distinct phases of the healing of the fracture. Ascorbic acid plays an important role in organization of the matrix through its action on development of connective fibers. Immediately before oxidation phosphatase shows its maximum activity. Each substance acts at a definite stage in the process.

Experiments on the effects of radiation on fracture healing were discussed by L Y Stefanenko⁵⁷⁶. The author found in experimental fractures in rabbits that trypan blue introduced into the blood stained the spinal cord in the areas corresponding to the involved extremity. Ultraviolet irradiation of the skin increased the rate of healing by its action on the sympathetic nervous system. On this basis, quartz lamp irradiation was used over the fracture in 120 cases. The author stated that healing took place in thirty-seven days in closed fractures, forty days in open fractures and forty-five days in gunshot fractures.

Other observations on the effects of the sympathetic nerves on healing of fractures were made by E Bohm and G Flieger⁵⁷⁷. It was assumed that the pain of fractures induced a vasomotor reflex or vascular cramp around the site. This leads to edema and articular stiffness. In the region of joints, injection of procaine hydrochloride prevents pain and tends to hasten healing. The authors fractured the fibula in rats and, in one group, administered 0.2 cc of 1 per cent procaine hydrochloride into the site of the fracture. Injections were given daily for one week, on alternate days in the second week and every third day during the third week. Hyperemia at the site of the fracture set in more promptly in the animals that received injections of procaine hydrochloride. Healing was more rapid in this group also and consolidation of the callus was completed earlier.

575 Roche, J, and Martin-Poggi, R. Sur les roles de la vitamine C et de la phosphatase dans la formation de la substance osseuse au niveau des cals de fracture, *Compt rend Acad d sc* **213** 668-670 (Nov 10) 1941

576 Stefanenko, L Y. New Developments in the Treatment of Fractures. *Khirurgiya* 1944 no 10 pp 97-104

577 Bohm, E, and Flieger, G. The Influence of Local Injections of Procaine Hydrochloride on the Healing of Fractures, *Acta chir Scandinav* **89** 97-112 1943

(To Be Continued)

TRAUMATIC RUPTURE OF THE LIVER WITHOUT PENETRATING WOUNDS

A Study of Thirty Two Cases

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THIS paper is based on 32 cases of traumatic rupture of the liver without penetrating wounds studied by us at Harlem Hospital. The present report covers cases observed during the period from Jan. 1, 1935 to Jan. 1, 1946, and a few scattered cases of which the records are still available which occurred prior to this period. In all the cases in this series operation or autopsy proved the liver to be injured.

Subcutaneous rupture of the liver due to trauma is not so infrequent as one is led to believe by the scattered reports in the literature. In a study from this hospital of traumatic subcutaneous rupture of the normal spleen,¹ covering the period from Jan. 1, 1928 to Sept. 1, 1938, it was shown that approximately 20,000 patients were admitted to the Traumatic Service of Harlem Hospital. Eighteen of these patients had subcutaneous rupture of the liver. This indicates roughly an incidence of 1 to 1,111. In the present series there are 27 cases of subcutaneous rupture of the liver (excluding 5 scattered cases) due to trauma in 34,000 admissions to the traumatic service during the period covered by this report. This indicates roughly an incidence of 1 to 1,259, which compares closely to the foregoing figures and to the figure of 1 to 1,300 reported by Thorlakson and Hay² from the Winnipeg General Hospital.

The liver is the largest intra-abdominal organ and it would be reasonable to expect it to be the most frequently injured. In a study of 365 cases of subcutaneous injury to the solid viscera, Edler³ reported

Read at the meeting of the Harlem Surgical Society, May 1, 1946.

1 Wright L. T. and Prigot A. Traumatic Subcutaneous Rupture of the Normal Spleen. *Arch Surg* 39:551-576 (Oct) 1939.

2 Thorlakson, P. H. T. and Hay, A. W. S. Rupture of the Liver. *Canad M A J* 20:593-598 (June) 1929.

3 Edler, L. Die traumatischen Verletzungen der parenchymatösen Unterleibsorgane (Leber, Milz, Pankreas, Nieren). *Arch f klin Chir* 34:343-409 1887.

the liver to be involved in 189 cases, and the spleen, kidney and pancreas in 176 cases. Although this high percentage was not borne out in a study by us of rupture of the normal spleen without penetrating wounds, the present series shows a greater frequency of injury to the liver (table 1). Combining the two series shows that the liver and spleen are injured in about the same number of cases and that together they make up 72 per cent of all intra-abdominal injuries.

Our experience shows that seasonal and yearly variations are unimportant. It is of interest to note, however, that during the period of gasoline rationing, 1942 to 1945 inclusive, only 1 case is noted.

TABLE 1—Incidence of Rupture of the Liver and Other Abdominal Viscera Without Penetrating Wounds in Two Series of Cases

Organ Ruptured	Present Series of Cases 1935-1946		Previous Series of Cases 1923-1933		Totals	
	Number	Percentage	Number	Percentage	Number	Percentage
Liver*	27	23.6	18	25.6	45	33.5
Spleen	23	30.7	30	47.6	53	23.4
Intestines	16	21.3	11	17.5	27	19.5
Mesentery	2	2.7	3	4.7	5	3.6
Pancreas	2	2.7	1	1.6	3	2.2

* Five cases not included in the 27 occurred between 1935 and 1938. They have never however been described before. The cases of ruptured spleen, intestines, mesentery and pancreas do not overlap in the two series of cases.

TABLE 2—Trauma in Cases of Rupture of the Liver

Traumatic Agent	Number of Cases	Percentage
Struck by motor vehicle	19	39.4
Fall from window	8	20.0
Fall down stairs	2	6.2
Assault and battery	1	3.1
Struck by streetcar	1	3.1
Undetermined	1	3.1

As shown in table 2, the motor vehicle is the traumatic agent in the greatest number of cases. In the 19 cases caused by motor vehicles, in only 1 instance did the history obtained indicate that the vehicle passed over the body of the injured.

Correlation of the age and sex incidence with the type of trauma reveals some interesting facts (table 3). Twenty-one cases or 65.6 per cent occurred in males and 11 or 34.4 per cent in females. Of the 19 cases involved in motor vehicle accidents, 13 or 68.4 per cent occurred in males and 6 or 31.6 per cent in females. The 8 cases due to falls from windows show the sex distribution to be equal. Two males fell down stairs. The 1 case of assault and battery involved a female, 1 male was struck by a streetcar. In 1 male no history of trauma was elicited, but he also had a ruptured spleen.

In the youngest age group, 2 to 5 years it will be noted that the 2 cases were caused by falling out of windows. As children become older and escape from parental care, accidents in the home decrease and those outdoors increase.

For the ten year period 15 to 24 years inclusive, we have no cases. In this age group the young adult is either so agile that injury is avoided or so reckless that the injury is almost immediately fatal and hospitalization is not required.

A study of the types of lacerations and the lobes and surfaces of the liver involved in injury without penetrating wounds is of interest and reveals some important facts.

TABLE 3—Age and Sex of Patient Correlated with Trauma

Age and Sex of Patient Correlated with Trauma										
Age	Sex		Type of Trauma							Total
	Male	Female	Motor Vehicle	Fall from Window	Fall Down Stairs	Struck by Bus	Struck by Streetcar	Assault and Battery	Undetermined	
2		1								1
3		1		1						1
4	1									1
6		2	1							2
8	1		1							1
11		2	1							2
12	3	1	3	1						4
14	1					1				1
25	2				1					2
26	2	1	2							3
17	2		1	1					1	2
25		1		1						1
33	1		1	1						1
37		1								1
23	1		1					1		1
42	1		1							1
43	1		1							1
45	1		1							1
46	1		1							1
49	1				1					1
50	1		1							1
63	1		1				1			1
68		1	1							1
Total	21	11	19	7	2	1	1	1	1	32

The liver is the largest gland within the abdominal cavity. Its friability and its position, suspended at the base of a bony cage consisting of the vertebral column posteriorly, the firm costal margin laterally and the abdominal wall and xiphoid process of the sternum anteriorly, combine to render the liver vulnerable to direct injury and injury by contrecoup. The right lobe, being larger and less protected than the left, is more easily injured.

NATURE OF LACERATION

The nature of the laceration of the liver also varies. Moorhead's⁴ experience, as well as our own, reveals a tendency of the liver to split

⁴ Moorhead J. J. Traumatic Surgery, ed 2 Philadelphia, W. B. Saunders Company, 1923, p. 647.

and crack in more or less a stellate manner with considerable hemorrhage and escape of bile. The right lobe is not infrequently split and is usually the site of central ruptures. In our series we have no transverse lacerations. Wakeley⁵ believes that this type does not bleed so freely as the vertical laceration.

As is shown in table 4, the right lobe was injured in 27 cases, the left lobe in 2 cases and both lobes in 3 cases. The figures support

TABLE 4—*Lobes and Surfaces Involved in Ruptured Liver*

Case	Right	Left	Both	Free Blood in Peritoneal Cavity	Results of Abdominal Tap
1	Inferior surface			Large	Positive
2			Extensive	Large	None
3	Split			Pus and blood	Positive
4	Split			Large	Positive
5	Dome			Large	None
6	Lateral surface			Moderate	Positive
7	Anterior surface			Moderate	None
8	Dome			Large	Positive
9	Posterior surface			Moderate	None
10	Split			Large	Positive
11	Dome			Large	Positive
12	Split			Large	Positive
13	Dome			Moderate	None
14	Dome			Moderate	None
15	Dome			Large	None
16	Split			Large	None
17	Dome			Large	None
18	Dome			Large	None
19		Through and through		Large	Negative
20			Anterior surface	Large	None
21	Dome			Large	Negative
22			Anterior surface	Large	None
23	Central			Large	None
24	Dome			Large	Negative
25	Dome			Large	None
26	Anterior surface			Large	None
27	Dome			Large	Positive
28	Dome			Large	Peritoneal copy pos
29	Dome			Large	Positive
30	Posterior surface			Large	None
31		Posterior surface		Large	None
32	Posterior surface			Moderate	Positive

Bleeding—Small 0 to 200 cc. moderate 200 cc to 500 cc. large 500 cc and over

Moynihan's⁶ statement that the right lobe is injured six times as frequently as the left lobe.

A study of the surfaces of the liver injured shows the dome of the right lobe involved in 14 cases, the posterior surface in 3 cases, the

5 Wakeley, C. P. G. Hepatic Injuries. Clin J 65 437-442 (Nov.) 1936

6 Moynihan, B. Abdominal Operations. Philadelphia W. B. Saunders Company, 1926 vol 2 p 236

anterior surface in 3 cases the inferior surface once and the lateral surface once. The posterior surface of the left lobe was involved once and the anterior surface of both lobes twice. In all the posterior surface was involved in only 4 cases. This tends to disprove the statement current in the literature that most ruptures are said to occur along the posterior inferior surface owing to the fact that during injury the liver is thrown against the vertebral column. In 6 of our cases the liver was actually split, the right lobe five times and the left lobe once. We have 1 case of central rupture. In table 5 we compare our experience in the frequency of involvement of various surfaces of the liver with that of Lamb.⁸

The amount of blood in the abdominal cavity or under the capsule in rupture of the liver is usually moderate or large in amount. The reasons for copious hemorrhage are as follows: the thin-walled hepatic veins are without valves and do not retract or contract, blood mixed with bile does not clot so easily, the respiratory movements of the

TABLE 5—Frequency of Involvement of Various Surfaces of the Liver

Surface	Lamb's Series Percentage	Our Series Percentage
Dome	41.0	43.7
Inferior	25.0	5.1
Anterior	6.3	21.8
Posterior	6.0	12.5
Lateral	12.5	3.1

diaphragm aggravate the injury, hepatic tissue is friable, easily displaced by hemorrhage and therefore does not act as a tampon. In all our cases there was a moderate or large amount of blood in the peritoneal cavity. In 1 case the patient refused operation for eight days, and pus and blood were found in the peritoneal cavity at operation. We use the term "moderate" to denote 200 to 500 cc. of blood and clots, below that figure, "small," and above it, "large."

How much trauma is necessary to cause rupture of the liver? In a paper on rupture of the spleen without penetrating wounds⁷ we showed that the trauma could be mild, therefore associated lesions are not common. Of 30 cases of rupture of the spleen without penetrating wounds, in 13, or 43.3 per cent, there were no associated lesions. In traumatic subcutaneous rupture of the liver, there were no associated lesions in 10, or 31.3 per cent. The trauma therefore necessary to cause rupture of the liver is usually severe.

- 7 O'Neill, J. N. Traumatic Rupture of the Liver. *California & West Med.* 54: 68-70 (Feb) 1941.
8 Lamb, C. A. Rupture of the Liver. *New England J. Med.* 221: 855-859 (Nov. 30) 1939.

Robin⁹ and others have reported rupture of the liver in cases due to minimal trauma, but Sciacca,¹⁰ in studying spontaneous rupture of the liver and cases with minimal trauma, came to the conclusion that in such cases the parenchyma of the liver is not normal. Devic and Beriel¹¹ stated that "in traumatic rupture, the rupture is the cause of the hemorrhage. In spontaneous rupture, the hemorrhage is the cause of the rupture."

Since the trauma in rupture of the liver without penetrating wounds is severer, associated lesions are commoner. In the present series we

TABLE 6—Associated Lesions in Twenty-Two Cases of Rupture of the Liver

Case No	Lacerations							Fractures			Rupture		
	Brain	Lung	Kidney	Heart	Stomach	Bladder	Spleen	Ribs		Skull	Multiple	Compound	Spinal
								Left	Right				
1	1		1							1			
2							1				1	1	Fall
3	1												Fall
4											1		Automobil
5									1				Automobil
6		1			1				1				Streetcar
7													Automobil
8	1									1			Automobil
9			1										Fall
10		1						1				1	Automobil
11								1	1				Automobil
12											1		Fall
13		1		1									Automobil
14		1									1		Fall
15	1						1						Automobil
16												1	Automobil
17											1		Automobil
18	1		1										Fall
19												1	Automobil
20						1							Automobil
21											1		Automobil
22													No history
Total	5	4	3	1	1	1	2	2	3	2	5	3	2

have but 10 cases without associated lesions. Of these 10, 5 were due to motor vehicle accidents, 2 were caused by falls from windows, 2 by falling down stairs, and 1 was the result of assault and battery.

The frequency and severity of the various associated lesions in the order of their occurrence is shown in table 6. There were 22 cases in

9 Robin, I. G. Case of Ruptured Liver Due to Trivial Violence. *Guy's Hosp Rep* 84:100-103 (Jan) 1934.

10 Sciacca, F. Le rotture quasi spontanea del fegato, *Polichinico (chir)* 44:254-263 (May) 1937.

11 Devic, E., and Beriel, L. L'apoplexie hepatiche dans la syphilis. Considerations sur les ruptures spontanees du foie, *Ann de dermat et syph* 7:642-665 1906.

which severe associated lesions were present. The traumas in these cases were as follows: 14 motor vehicle accidents, 6 falls and 1 street-car accident, in the last case there was no history of trauma but we believe that the patient was injured while under the influence of liquor because he also had a ruptured spleen.

From table 6 one can study the frequency of associated lesions. Lacerations of the brain and spinal cord proved by spinal tap and ruptured spleen each occurred five times. In 5 cases there were multiple fractures, simple and compound (exclusive of fractures of ribs). It is of interest to note that fractures of the ribs appeared five times in 4 cases, the right side being involved in 3 cases, both sides in 1 case and the lower ribs on the left side in 1 case. In all these cases the right lobe of the liver was involved in the rupture.

CLASSIFICATION OF TRAUMATIC RUPTURE

Since the associated lesions occur so frequently and are so severe as to obscure the diagnosis, each of these cases must be studied and evaluated individually. We shall base our classification of traumatic rupture of the liver on the cases in which no complications were present.

There is considerable variation in the clinical manifestations of hepatic rupture due to the character of the internal concealed hemorrhage which dominates the symptoms, and classification therefore is not easy. It is clear that any classification must be elastic.

Hitzrot's¹² and Moynihan's⁶ classifications are based on the pathologic findings. Hitzrot's classification is as follows:

- 1 Subcapsular rupture
 - a Central
 - b Subcapsular
- 2 Rupture of both capsule and parenchyma

Moynihan proposed the following classification:

- 1 Rupture of the liver with laceration of Glisson's capsule
- 2 Separation of the capsule with subcapsular hemorrhage
- 3 Central rupture with formation of abscess or cyst

Inasmuch as the clinical manifestations of traumatic rupture of the liver without penetrating wounds not infrequently bear no relation to the severity of the rupture, we offer a classification dependent on the rate of hemorrhage. The rate of hemorrhage at times may not be in proportion to the amount of damage to the liver. Vance,¹³ studying cases which came to autopsy, confirmed our impression. He found in

¹² Hitzrot J. M. Subcutaneous Injuries of the Liver, *Ann Surg* 66:50-63 (July) 1917.

¹³ Vance B. M. Subcutaneous Injuries of Abdominal Viscera. Anatomic and Clinical Characteristics, *Arch Surg* 16:631-689 (March) 1928.

a study of 21 cases that 33.3 per cent of the patients died at the site of injury, 38.1 per cent died within the first six hours and 28.6 per cent lived a sufficient length of time for an adequate clinical study.

In our opinion there are four clinical types as follows:

- 1 Massive hemorrhage, causing almost immediate or sudden death
- 2 Acute hemorrhage producing shortly after the injury a state of shock which rapidly becomes deeper
- 3 Repeated small hemorrhages, the patient enters the hospital in good condition but shows signs of slow progressive hemorrhage, increasing anemia, a rising pulse rate, a fall in blood pressure and progressive weakness or the signs and symptoms may disappear except for pain in the liver area and then recur gradually or with dramatic suddenness; the reappearance of signs of internal concealed hemorrhage may occur at any time from one day to even months later¹⁴
- 4 Spontaneous cure, the patient shows evidence of injury to the liver with signs of internal concealed hemorrhage; symptoms disappear in due time

A presumable case of type 4 was seen recently.

The patient, a man 40 years of age, fell three stories. He was brought into the hospital in extreme shock. His blood pressure was 90 systolic and 60 diastolic, and the pulse rate was 130. Rigidity of the upper part of the abdomen was present on the right side. Roentgen rays showed pneumothorax of the right side, fracture of the seventh, eighth, ninth and tenth ribs on the right side in the nipple line and fractures of the transverse processes of the first, second, third, fourth and fifth lumbar vertebrae on the right. Abdominal tap was done six hours after admission, and 2 cc of blood was obtained. The patient was seen in consultation by various members of the staff. Their opinion was divided as to the seriousness of any intra-abdominal injury. He was carefully observed, and at the end of thirty-six hours his abdominal symptoms had subsided. He was treated conservatively. At the end of seventy-two hours he presented no abdominal signs of any character. At the end of a week he was out of bed and wanted to go home.

Because of the location of the multiple fractures of the ribs over the right lobe of the liver, together with fractures of the right transverse processes of the lumbar vertebrae, and the blood obtained from the abdominal cavity by means of abdominal tap from the right upper quadrant, it is most likely that the bleeding was from a small laceration due to rupture of the right lobe of the liver. This case, therefore, is presumably one of spontaneous recovery.

14 (a) Robertson D. E., and Graham R. R. Rupture of the Liver Without Tear of Capsule. *Ann Surg* 98:899-903 (Nov.) 1933. (b) Wulsten J. Zur Klinik und Pathologie der zentralen Leberruptur. *Beitr z klin Chir* 153:424-436, 1931. (c) Corriden T. F. Subcapsular Rupture of Liver in Child. *Surgery* 8:446-455 (Sept.) 1940. (d) Christopher F. Rupture of Liver. *Ann Surg* 103:461-464 (March) 1936. (e) Robertson, D. E. Rupture of Liver Without Tear of Capsule, *ibid* 106:467-469 (Sept.) 1937. (f) Brandberg R. Beitrag zur Klinik der traumatischen Leberverletzungen bei unverletzter Kapsel. *Acta chir Scandinav* 63:321-345 1928.

In our series we have 1 case of massive hemorrhage. In this case the right lobe of the liver was found to be split.

In case 16 of table 4 a 6 year old girl was said to have been struck by an automobile cab about 100 ft before admission to the hospital. Physical examination revealed a girl in profound shock, her blood pressure was not obtainable. The abdomen was soft. The patient died fifteen minutes after admission. The necropsy revealed laceration of the right lobe of the liver practically split in half in a sagittal direction.

In the group in which acute hemorrhage occurs the patient although brought to the hospital shortly after the accident is in shock on admission. The patient's condition becomes progressively worse as the shock deepens. This group is illustrated by the following case.

The patient in case 9 of table 4 a 12 year old girl was said to have been struck by an automobile shortly before admission. Physical examination revealed a girl in shock, with a blood pressure of 85 systolic and 60 diastolic. The abdomen was soft with slight tenderness in the upper part. The patient was given anti-shock therapy, and despite this the blood pressure fell to 70 systolic and 50 diastolic. The abdomen became more tender in the left upper quadrant with slight rigidity. A diagnosis of ruptured spleen was made and an operation performed. At operation a 5 inch (12.7 cm) laceration of the posterior aspect of the right lobe of the liver was found. There was a moderate amount of blood in the peritoneal cavity. The tear in the liver was packed with gauze. Postoperatively the patient went downhill and died the next day with a temperature of 104 F. Postmortem diagnosis was rupture of the liver, hemorrhage and shock.

In cases of repeated small hemorrhages after the initial injury, the patient's condition gradually becomes worse with obscure abdominal symptoms and progressive weakness, the patient may be relatively free of symptoms except for pain in the area of the liver, until a mass appears in the right upper quadrant or until the liver becomes enlarged. This period, relatively free from symptoms, may be suddenly terminated by a dramatic episode of sudden onset of acute hemorrhage or the reappearance of signs of slow hemorrhage. The following case is illustrative.

The patient in case 5 of table 4, a 46 year old man fell down a flight of stairs two days before admission. During the fall he struck his abdomen. The patient was not unconscious but felt weak. After the fall he experienced steadily increasing generalized abdominal pain, worse on motion. He felt weaker. Physical examination revealed a well developed, well nourished man. Blood pressure was 146 systolic and 74 diastolic. There was tenderness over the right costal margin and rigidity in the right upper quadrant. Laboratory studies revealed an icteric index of 27, a white blood cell count of 19,600 and a red blood cell count of 4,900,000, the hemoglobin value was 80 per cent.

Exploratory laparotomy revealed two deep lacerations, one 2 3/4 inches (7 cm) long the other 2 inches (5.1 cm) in length on the dome of the liver. There was 500 cc of free blood and clots in the peritoneal cavity. Lacerations of the liver were packed with gauze. On the second postoperative day a type 20 pneumonia of the lower lobe of the right lung developed, and the patient died on the third postoperative day. Necropsy revealed lacerations of the liver, lobar pneumonia, infarction and necrosis of the middle portion of the right lobe of the liver.

We have no cases of repeated small hemorrhages with formation of a mass in the area of the liver, but they have been reported in the literature.¹⁴ Robertson's and Graham's cases showed a slowly developing mass in the hepatic area. In central rupture the liver may be found enlarged and palpable.

As far as we have been able to ascertain, no cases of spontaneous recovery from rupture of the liver have been studied at this hospital, except the 1 presumable case (cited earlier in the paper) which is not included in this series. In over 4,000 autopsies no case of traumatic cyst of the liver has been noted. Such cases, however, have been noted in the literature. Hawthorne, Oaks and Neese¹⁵ reported a case which showed inspissated blood in the gallbladder at operation. The patient made an uneventful recovery, but continued to vomit blood for a short while after operation because blood had seeped down the biliary tract into the duodenum.

TABLE 7—*Gross Pathologic Changes of Liver in Rupture*

Clinical Class	Lobe and Surface Involved	Type of Laceration
Massive hemorrhage	Right lobe	Split
Acute hemorrhage	Dome of right lobe	Extensive laceration
	Posterior aspect right lobe	5 in (13 cm) deep
	Dome of right lobe	3 in (7.6 cm) deep
	Dome of right lobe	Several deep lacerations
	Dome of right lobe	3 in deep
Repeated small hemorrhages	Right lobe	Split
	Posterior surface, right lobe	Large stellate laceration
	Posterior surface right lobe	3 in deep
	Posterior surface right lobe	Large irregular laceration

In summation of our 10 uncomplicated cases, we found the following

Massive hemorrhage	1 case
Acute hemorrhage	5 cases
Repeated small hemorrhages	4 cases

The greatest number of cases, therefore, fall into the group of acute hemorrhages or repeated small hemorrhages.

The pathologic changes in the liver are not characteristic, and the symptoms are not infrequently out of proportion to the pathologic changes (table 7).

DIAGNOSIS

The diagnosis of rupture of the liver without penetrating wound in the uncomplicated case is difficult, and it is extremely so in those cases in which severe complications occur. It must also be remembered that symptoms of intra-abdominal injury may not develop for six hours

¹⁵ Hawthorne, H. R., Oaks, W. W., and Neese, P. A. Liver Injuries with Case Report of Repeated Hemorrhages Through Biliary Ducts, *Surgery* 9:358-360 (March) 1941.

or more¹⁶ There are no signs or symptoms which are pathognomonic of this condition, and one must evaluate each case on its own merit The signs of rupture of the liver without penetrating wound are chiefly hemorrhage, shock and peritoneal and diaphragmatic irritation In the rare case of subcapsular rupture, a tender mass may be palpable as has been reported in the literature In central rupture blood—because of its entrance into the biliary tract—may appear in the vomitus or the liver may become enlarged However because of the severity of the concealed hemorrhage it is essential that rupture of the liver be recognized early, so that proper treatment may be instituted without delay

Abdominal pain is the commonest complaint This pain is usually severe in character and worse on deep respiration and on moving In all our cases, except in 8 in which the patients were unconscious or in profound shock, this symptom was either present at time of admission or it developed while the patient was under observation

Radiation of the pain to the right or left shoulder (Kehr's sign) was not noted McKnight¹⁷ expressed the opinion that if the dome of the liver is involved pain is referred to the shoulder, and if the inferior surface is involved discomfort is referred to the waist line Pain referred to the shoulder, if present, is helpful, but it is frequently absent None of our patients had this pain

Other symptoms of rupture of the liver are the symptoms of internal concealed hemorrhage

Vomiting occurs not infrequently as a reaction to trauma However, vomiting should be studied because in central rupture of the liver, blood may get into the biliary tree and appear in the vomitus

The physical findings are more helpful All cases in the group of massive hemorrhage and acute hemorrhage showed signs of shock Those in the group of repeated small hemorrhages did not show these signs on admission, but as they were studied the fact of internal hemorrhage soon became evident We, in our series, like Dean Lewis and I R Trimble,¹⁸ did not observe bradycardia, which Finsterer and others¹⁹ regarded as a characteristic symptom

16 Butler, E. Injuries of Chest and Abdomen Surg, Gynec & Obst 66 448-453 (Feb) 1938

17 McKnight, R. B. Postoperative Physiological Studies in Case of Traumatic Rupture of Liver, with Recovery, Am J Surg 8 542-547 (March) 1930

18 Lewis D, and Trimble, I R. Subcutaneous Injuries of Abdomen Ann Surg 98 685-697 (Oct) 1933

19 (a) McKnight¹⁷ (b) Finsterer H. Zur Diagnose und Therapie der Leberverletzungen, Beitr z klin Chir 119 598-616, 1920 (c) Graham, A J. Subcutaneous Rupture of Liver, Ann Surg 86 51-61 (July) 1927 (d) Orth, O. Casuistischer und experimenteller Beitrag zur Leber- und Gallengangsruptur, Arch f klin Chir 101 369-375, 1913 (e) Erdely, J. Geheilte multiple Leberruptur nebst Darmverletzung Beiträge zur Diagnostik und Therapie der subkutanen Leberruptur, Deutsche Ztschr f Chir 198 110-117, 1926

The circulatory system showed the variations as noted in table 8. Seventy-two per cent of all patients entered the hospital with a systolic blood pressure below 90 mm of mercury.

The location of site of maximum tenderness is misleading. In 1 case maximum tenderness was in the left upper quadrant, and diagnosis of ruptured spleen was made. The pathologic change found was rupture of the posterior surface of the right lobe of the liver. Table 9 shows the location of the pain and the physical findings of abdominal tenderness, rigidity and rebound tenderness.

Palpation of an abdominal mass in the hepatic area or an enlarged liver may be diagnostically helpful when present. Such masses are

TABLE 8—*Blood Pressure in Rupture of Liver*

Blood Pressure on Admission	Lived	Died	Total	Percentag
Not obtainable	2	8	10	31.3
Systolic below 60	0	2	2	6.2
Systolic 60 to 90	0	11	11	34.4
Systolic 91 to 120	2	4	6	18.8
Systolic 121 to 140	2	0	2	6.3
Over 140	0	1	1	3.1

TABLE 9—*Localization of Abdominal Pain, Tenderness, Rigidity and Rebound Tenderness in Hepatic Rupture*

Location	Pain	Tenderness	Rigidity	Rebound
Generalized	9	9	6	2
Upper part of abdomen	4	2	2	3
Lower part of abdomen	3	2	2	3
Right upper quadrant	2	3	4	3
Left upper quadrant	2	2	1	
Right lower quadrant	3	3	1	
Left lower quadrant	1	1	1	

usually found in subcapsular or central rupture of the liver. Jaundice is rare but may appear in forty-eight to seventy-two hours after injury in some cases.

Laboratory studies, especially of the cellular elements and the hemoglobin content of the blood, are important, however, at times they may be misleading. Repeated blood cell counts and hematocrit determinations should be done in all cases until the diagnosis of some intra-abdominal injury is established. Hemoconcentration at first may conceal the fact of hemorrhage.

Examination of the urine should only be done to rule out pathologic changes of the urinary tract. If blood is found in the urine, it is wise to rule out other causes of concealed hemorrhage.

There are certain diagnostic procedures which may facilitate the diagnosis of rupture of the liver. Roentgenography may show a high diaphragm on the right side. Burke and Madigan reported the use of thorotrast²⁰ (colloidal thorium dioxide) to outline the liver. However, this method requires at least four hours and is of doubtful value.

The abdominal tap and peritoneoscopy are invaluable as aids in the diagnosis of rupture of abdominal viscera without penetrating wounds. The abdominal tap, performed with a spinal needle in all four abdominal quadrants, has in our hands been extremely helpful. In fact, we feel it is inexcusable to neglect to make an abdominal tap in all cases in which intra-abdominal injuries are suspected. This is especially true in cases in which associated lesions mask the abdominal complications. As was shown in our paper on ruptured spleen, the test is accurate. In our present series of rupture of the liver, the tap was employed in 15 cases and failed to disclose free blood in only 3 cases (table 4). The finding of blood by abdominal tap is indicative of intra-abdominal injury, whereas failure to find it does not rule out intra-abdominal injury. No "false positive" results were obtained. Peritoneoscopy was employed once, with a positive result.

Our experience with the abdominal tap has been satisfactory and we do not hesitate to use it. It is especially helpful in cases in which the diagnosis is obscure, in cases in which the patient is admitted unconscious and in shock and in cases in which the physical signs are obscured either by fractured ribs or by concealed hemorrhage into cavities of the body other than the peritoneal.

The diagnosis of rupture of the liver without penetrating wound is not an easy one to make. When the history of trauma bears a direct relation to the chain of symptoms of abdominal pain and to the finding of abdominal tenderness and spasm with evidence of concealed hemorrhage, a presumptive diagnosis of ruptured liver may be made. The finding of a mass in the hepatic area or an enlarged liver is helpful but rare. Kehr's, Ballance's and Cullen's signs are helpful when present, their absence is of no significance. Bradycardia is significant when present, but is the exception rather than the rule.

First, it is important to rule out nonsurgical conditions.

There are many conditions which may obscure the diagnosis of rupture of the liver. Contusion of the abdominal wall gives a picture similar to that of rupture of the liver without penetrating wounds; however, in cases of contusion, the pulse rate, blood pressure and blood

²⁰ Burke, W. F., and Madigan, I. P. Roentgenologic Diagnosis of Rupture of Liver and Spleen as Visualized by Thorotrast. *Radiology* 21: 580-583 (Dec.) 1933.

cells are generally normal. The picture remains normal with abatement of the patient's symptoms.

Fractures of the ribs with shock due to hemorrhage into cavities other than the peritoneal cavity give a picture closely simulating ruptured liver. Here the abdominal tap is of inestimable value.

Once the diagnosis has placed a rupture of a solid viscus within the abdominal cavity the chances are equal of its being either spleen or liver, and not infrequently it is both.

In conclusion, we may say that the diagnosis of subcutaneous rupture of the liver is difficult because there is considerable variation in the clinical manifestation of this condition, owing to the character of the internal concealed hemorrhage which dominates the symptoms. In general the trauma which produces this condition is usually severe, causing other associated lesions which mask the rupture. The abdominal tap is an invaluable aid in the diagnosis of this condition and when the results are negative, it should be repeated.

TREATMENT

The treatment of traumatic rupture of the liver is surgical. Conservative treatment has been variously reported as fatal in 75 per cent to 96 per cent of the cases.²¹ Operative intervention is imperative and delay increases the operative risk²² and the probability of infection.

Preoperative treatment of this condition is directed to the establishment of an accurate diagnosis and to the combating of existing shock. In preparation of the patient for operation, the treatment must differ in individual cases. However, preoperative enemas are to be avoided for fear that the increase in intra-abdominal pressure due to straining at stool may destroy more hepatic tissue and increase the bleeding. Spinal anesthesia is avoided because there may be associated lesions of the intestinal tract.

Shock must be combated in the usual manner and large quantities of blood given before, during and after operation by the slow drip method. Autotransfusion has been recommended and used.²³ In fact, White²⁴ performed the first autotransfusion in this country and the

21 Ashhurst A. P. C. *Surgery Its Principles and Practice*, ed 4, Philadelphia Lea & Febiger, 1931, p 874. Deaver, J. B., and Ashhurst, A. P. C. *Surgery of Upper Abdomen*, ed 2, Philadelphia P. Blakiston's Son & Co., 1921, p 598.

22 Thole, F. in von Bruns P. *Neue deutsche Chirurgie*, ed 4, Stuttgart, Ferdinand Enke, 1912.

23 Watson C. M., and Watson J. R. Autotransfusion. Review of American Literature with Report of Two Additional Cases. *Am. J. Surg.* 33: 232-237 (Aug.) 1936. Bloch O. E. Ruptured Liver with Recovery, Kentucky M. J. 28: 152-153 (March) 1930.

24 White, C. S. Rupture of Liver. *Surg. Gynec. & Obst.* 36: 343-347 (March) 1923.

case was one of subcutaneous rupture of the liver. We do not use this procedure for two reasons: (1) the blood may be mixed with bile, and (2) it may contain toxins, the product of the autolysis of hepatic tissue.¹⁸ Allen²⁵ reported a death by anuria fifty-six hours after autotransfusion in a case of ruptured liver.

Is exploration necessary in all cases of suspected hepatic injury? The answer is yes. There are three factors which must be considered, namely, bleeding, destruction of hepatic tissue and associated intra-abdominal injuries. Many surgeons have noted that by the time operation was performed, bleeding from the liver had ceased. Tellmanns²⁶ experimentally removed wedges of liver from animals without suturing the defect. The animals recovered. Therefore Hinton²⁷ advised that conservative treatment should be followed.

We cannot support this view, even though the bleeding may have a tendency to stop spontaneously in a few cases. The fact of a high mortality rate in conservative treatment cannot be denied. Thompson,²⁸ too, advised that conservative treatment should be followed.

In subcutaneous rupture of the liver, the biliary tree is also disturbed and considerable bile may be spilled into the abdominal cavity resulting in bile peritonitis. Pieces of hepatic tissue may be so damaged and its circulation so impaired as to result in necrosis. All damaged hepatic tissue must be removed. For Boyce and others²⁹ have expressed the opinion that a toxin is elaborated as a result of degeneration of hepatic tissue and that this toxin plays an important role in the so-called hepatorenal syndrome. Branch³⁰ reported 2 cases of rupture of the liver in which the patient made a good recovery in spite of a piece of necrotic liver not removed at the time of operation.

Should the patient be subjected to surgical treatment at once? Branch³⁰ stated the belief that "exploration should be undertaken in

25 Allen, A. W. *Internal Injuries Without Penetrating Wounds*, New England J. Med. **205** 34-38 (July 2) 1931.

26 Tellmanns, H. *Experimentelle und anatomische Untersuchungen über Wunden der Leber und Niere. Ein Beitrag zur Lehre von der antiseptischen Wundheilung*. Virchows Arch. f. path. Anat. **78** 437-474 1879.

27 Hinton, J. *Injuries to Abdominal Viscera. Their Relative Frequency and Their Management*, Ann. Surg. **90** 351-356 (Sept.) 1929.

28 Thompson, J. W. *Subcutaneous Injuries to Liver*, Internat. J. Med. & Surg. **43** 540-543 (Oct.) 1930.

29 Boyce, F. F. *The Role of the Liver in Surgery*. Springfield, Ill., Charles C. Thomas, Publisher, 1941, p. 90. Boyce, F. F., and McFetridge, E. M. *Role of Liver Damage in Mortality of Surgical Diseases*, South. M. J. **31** 35-39 (Jan.) 1938. *Autolysis of Tissue in Vivo. Experimental Study with Its Clinical Application in Problem of Trauma to Liver*, Arch. Surg. **34** 977-996 (June) 1937.

30 Branch, C. D. *Injury to Liver. Report of Two Cases*, Ann. Surg. **107** 475-477 (March) 1938.

every case of suspected liver injury in which the patient is not actually moribund, or in which he can be brought out of shock and rendered reasonably fit for exploration" Noble³¹ stressed the importance of early diagnosis and expressed the belief that "surgery, done after development of symptoms secondary to rupture of the liver, is done too late" Cheyne and Burchard³² stated the opinion that if "injury of the liver is severe, the patient will not recover from the primary shock until the hemorrhage is arrested and therefore operation is urgent"

We believe that to delay an operation, to pour blood into a person who is having a severe intra-abdominal hemorrhage, may gain little and may delay operation to such a point that no operative procedure can be carried out. We feel that exploration should be done as soon as the diagnosis is made, although supportive measures, such as slow drip transfusions of blood, intravenous administration of dextrose and isotonic solution of sodium chloride and blood plasma, are invaluable and should be begun simultaneously.

Early operation may also tend to eliminate complications such as infection, fatty embolism and hepatic tissue embolism.

In one of our cases case 3 of table 4, the patient refused operation for eight days. At operation an extensive infection was found in the peritoneal cavity. Rutherford³³ reported a case of rupture of the liver in which there was no operation and in which a subdiaphragmatic abscess occurred one and one-half years after the injury.

Straus, Willer and Bauer³⁴ have reported cases of pulmonary embolism caused by hepatic tissue. Engel³⁵ has reported a case of fatty embolism following rupture of the liver.

Surgical treatment, then, is the treatment of choice, and it should be done early. There is a wide difference of opinion as to the surgical treatment of rupture of the liver. All methods deal with the control of bleeding, the repair of the defect and drainage.

31 Noble, T. B., Jr. Traumatic Rupture of Liver in Children, Indianapolis M J **31** 91-94 (April) 1928

32 Cheyne, W. W. and Burchard, F. F. Manual of Surgical Treatment London, Longmans, Green & Company, 1903, pt 6, sect 2, p 107

33 Rutherford, S. E. Subdiaphragmatic Abscess One and One Half Years After Laceration of Liver, Canad M A J **41** 489-490 (Nov) 1939

34 Straus, R. Pulmonary Embolism Caused by Liver Tissue Arch Path **33** 69-71 (Jan) 1942 Willer, H. Ueber Lebergewebsembolie und das gewebliche Verhalten aus dem Verbinde gelöster Leberstücke in Organismus, Centralbl f allg Path u path Anat **62** 209-213 (April 20) 1935

35 Engel, H. Fettembolie einer tuberkulösen Lunge in Folge von Leberruptur München med Wchnschr **48** 1046-1048 (June 25) 1901

Steam³⁶ and cautery³⁷ have been used to control bleeding locally. Kocher³⁸ used compression clamps to crush the liver. These clamps were removed in twenty-four hours. For temporary control of hemorrhage, Pringle³⁹ advised digital compression at the foramen of Winslow, while Clementi and McDill⁴⁰ clamped the gastrophatic omentum with an enterostomy clamp.

Large sutures have been used to control bleeding and repair defects in the liver⁴¹. In order to prevent sutures from tearing through the parenchyma, various types of decalcified bone plates,⁴² free and attached omental strips⁴³ and fascial strips⁴⁴ have been used. Securing the liver to the abdominal wall in order to control hemorrhage has been advised⁴⁵.

Various types of gauze packs, and packing with muscle, omentum, fat and rubber dam have been used. Halstead⁴⁶ advised a light drain or a small pack. Pilcher⁴⁷ stated that he hesitates to use large gauze packing because of a belief that this plays a role in the causation of intestinal obstruction. We feel that in simple tears when the liver is not badly lacerated suture may be done with safety.

36 Snegirew, W. F. Der Dampf als blutstillendes Mittel. Deutsche med. Wchnschr. **20** 747 (Sept 20) 1894.

37 Ullman, E. Berichte aus den wissenschaftlichen Vereinen, Wien. med. Wchnschr. **47** 2244-2246 (Nov 22) 1902.

38 Kocher, E. T. Chirurgische Operationslehre, ed 4. Jena: Gustav Fischer, 1902, p. 348.

39 Pringle, J. H. Notes on the Arrest of Hepatic Hemorrhage Due to Trauma, Ann Surg. **48** 541-549, 1908.

40 Clementi. Le ultime modificazioni nella cura della ferite, relative in especial modo al materiale per le legature dei vasi sanguigne ed alle forgnatura, Centralbl. f. Chir. **34** 651-655 (Aug 23) 1890.

41 Kuznetsoff, M. M., and Pensky, I. P. Etude cliniques et experimentales, Rev. de chir., Paris **16** 501-521 and 952-992, 1896. Langenbuch, C. Ein Fall von Resection eines links-seitigen Schnurlappens der Leber, Berl. klin. Wchnschr. **25** 37-38 (Jan 16) 1888. Cullen, T. S. Surgery of the Liver, Surg., Gynec. & Obst. **4** 573-584 (May) 1907.

42 Ceccherelli, A., and Bianchi, A. Nuovo processo di sutura per l'emostasi del legato, Atti d. Cong. med. internaz. sez. chir. (1894) **4** 188-191, 1895.

43 Boljarski, N. Ueber Leberverletzungen in klinischer und experimenteller Hinsicht unter besonderer Berücksichtigung der isolierten Netzplastik, Arch. f. klin. Chir. **23** 507-547, 1910.

44 Beck, C. Surgery of the Liver. J. A. M. A. **38** 1063-1068 (April 26) 1902.

45 Chiari, O. M. Zur Versorgung von durch stumpfe Gewalt entstandenen Leberwunden. Wien. klin. Wchnschr. **34** 460 (Sept 22) 1921. Gillette, W. J. Surgery of the Liver. Surg., Gynec. & Obst. **1** 361 (Oct) 1905. Robertson^{14e}.

46 Halstead, A. E. Four Cases Requiring Liver Surgery, S. Clin. North America **3** 973-983 (Aug) 1923.

47 Pilcher, L. S. Massive Rupture of the Liver. Ann. Surg. **116** 827-832 (Dec.) 1942.

Recent work on the coagulum contact technic⁴⁸ of Sano and the use of fibrin foam, oxidized cellulose gauze or gelatin sponge "gelfoam" may not only be the best method of repairing the liver but also, because of the speed with which they can be used, may reduce the operating time and loss of blood and thereby reduce the mortality rate as well as the morbidity rate

The prognosis for rupture of the liver depends not only on the severity of the rupture but also on the severity of the associated lesions. In the present series of 32 cases, 6 patients lived. The gross mortality was 81.3 per cent. The high mortality in this series was due to the large number of cases with serious associated lesions. Of the 26 patients who died, 11 died within the first four hours of hospitalization and without benefit of surgical treatment. Two patients died, one after nine hours

TABLE 10—Comparative Mortality Rates for Rupture of the Liver Without Reference to Associated Lesions

Author	Number of Cases			Gross Mortality, with No Per Opera		No of Cases Lived		Nonoperative Mortality, with Per Opera		No of Cases Lived		Operative Mortality Per	
O'Neill ⁷	100	19	81	81.0	68	0	68	100.0	32	19	13	40.0	
Thorlakson -	11	0	6	54.5	3	0	3	100.0	8	0	3	37.5	
Lewis and Trimble ¹⁸	20	8	12	60.0	6	0	5	100.0	14	8	6	40.0	
Graham ^{19c}	11	6	5	45.4	2	0	2	100.0	9	6	3	33.3	
Allen ²⁰	24	8	16	66.6	2	0	2	100.0	22	8	14	63.6	
Hitzrot ¹²	10	7	3	30.0	1	0	1	100.0	9	7	2	22.5	
Lamb ⁸	60	19	41	68.3	26	0	26	100.0	34	19	15	44.0	
Wright, Prigot and Hill	32	6	26	81.3	17	0	17	100.0	15	6	9	60.0	

in the hospital and the other after four days in the hospital. The diagnosis was missed because it was obscured by an associated laceration of the brain. One patient died on the way to the operating room twenty-seven hours after admission. Diagnosis was at first masked by symptoms from a lacerated brain. Two patients refused operation, 1 patient had bilateral fractured ribs.

Fifteen patients were operated on for rupture of the liver, and 9 died. Our operative mortality is therefore 60 per cent. Seventeen were not operated on, and all died. The causes of death in cases in which there was operation were as follows: Three patients died in shock, 2 died with generalized peritonitis—they had associated rupture of the gastrointestinal tract, 1 died of pneumonia, 1 had a severe laceration of the brain, in 1 infarction of the liver developed with jaundice, 1 died because a rupture of the spleen was missed at operation.

48 Sano, M. E., and Holland, C. A. Coagulum Contact Technic in Traumatic Rupture of Liver in Dog and Man, *Science* 98:524 (Dec. 10) 1943.

Table 10 shows comparative gross mortality rates and operative mortality rates for cases of rupture of the liver. Operative mortality is dependent largely on the presence or absence of associated injuries and their character.

In our series in the 6 patients who lived, at operation the rupture of the liver was packed with gauze. Only 2 patients had associated injuries, 1 had a ruptured spleen, and splenectomy was done, the other had a fracture of the femur. The postoperative complications in this series were purulent discharge around the gauze packing, in 3 cases, and decubitus ulcer, in 1 case.

We have had no cases with secondary hemorrhage from the packed liver as reported by Robin.⁹ Clarke⁴⁹ reported a sequestrum of liver complicating recovery. McCorkle and Howard and others⁵⁰ reported hepatorenal syndrome complicating ruptured liver. In our series, none of the patients showed symptoms of hepatorenal syndrome, although 4 had infarction of the liver at necropsy, 2 had jaundice postoperatively, and 1 had free fragments of liver in the abdominal cavity at operation.

It is of interest to note that no patients in this series died a so-called liver death, while in a study⁵¹ of gunshot wounds of the abdomen from this hospital, it was observed that of 16 patients with hepatic injury 3 died a so-called liver death, which is characterized by high temperature, falling blood pressure, circulatory collapse, coma and death, in such cases the loss of blood is insufficient to cause the symptoms.

In our cases in which there was recovery, morbidity was as follows: twenty-three, forty-four, thirty-one, ninety-eight, sixteen and twenty days. Gauze packing was removed on the fourteenth, the thirty-sixth, the twenty-third and the fortieth day, the day on which it was removed was not stated in 2 cases.

49 Clarke R. Case of Liver "Sequestrum" Complicating Subcutaneous Rupture of Liver, *Brit J Surg* 28 544-548 (April) 1941.

50 McCorkle, H., and Howard, F. S. Severe Trauma to Liver with 'Hepatorenal Syndrome,' *Ann Surg* 116 223-230 (Aug) 1942. Furtwaengler, A. Diffuse Rindennekrose beider Nieren nach Leberruptur. Ein Beitrag zu den angiospastischen Krankheitsbildern in der Chirurgie. *Krankheitsforschung* 4 349-374 (June) 1927. Stanton, E. M. Immediate Causes of Death Following Operations on Gall Bladder and Ducts, *Am J Surg* 8 1026-1032 (May) 1930. Rosenbaum, J. Ein Beitrag zum Problem des entero-hepato-renal Syndroms (Anurie nach Leberschädigungen), *Deutsche Ztschr f Chir* 243 66-84, 1934. Helwig, F. C., and Schutz, C. B. Further Contribution to Liver-Kidney Syndrome. *J Lab & Clin Med* 21 264-277 (Dec.) 1935. Becker, F. Schwere Nierenchädigung nach Leberruptur, *Zentralbl f Chir* 63 674-677 (March 21) 1936. Orr, T. G. and Helwig, F. C. Liver Trauma and Hepatorenal Syndrome, *Ann. Surg* 110 682-692 (Oct) 1939.

51 Wilkinson, R. S., Hill, L. M., and Wright, L. T. Gunshot Wounds of the Abdomen. Review of One Hundred and Forty-Nine Cases. *Surgey* 19 415-429 (March) 1946.

SUMMARY

Thirty-two cases of rupture of the liver without penetrating wounds are discussed, showing that they are neither rare nor infrequent. A classification based on the rate of hemorrhage is presented. The abdominal tap is an invaluable aid as a diagnostic procedure. Differential diagnosis must exclude lesions causing hemorrhage elsewhere in the body. Associated lesions may mask signs and symptoms of ruptured liver. Treatment of ruptured liver is surgical. The use of fibrin foam, oxidizable cellulose gauze or "gelfoam," which are the new methods for the control of hemorrhage, are worthy of extensive trial in these cases. Mortality, gross and operative, for subcutaneous rupture of the liver is discussed. Mortality can be reduced by (a) early diagnosis so that immediate operation may be done, (b) the free use of blood, blood plasma and fluids in general to counteract coexisting hemorrhage and shock, (c) the use of penicillin and sulfonamide compounds to prevent infection, and (d) close teamwork on the part of the surgical and nursing staffs and by maintenance of a close watch over the patient throughout his hospital stay.

PARTIAL EXCISION OF THE MOTOR CORTEX IN TREATMENT OF JACKSONIAN CONVULSIONS

Results in Forty One Cases

COBB PILCHER, M D

W F MEACHAM, M D

AND

T J HOLBROOK, M D

NASHVILLE TENN

I believe that the only thing persistently physiologically abnormal in A is that some few cells of his thumb-center have become culminant

It is a pity that A cannot be rid of these worse than useless cells, but I know of no way of effecting this riddance. There is the surgical question of cutting out part of the cortex. —Hughlings Jackson,¹ 1890

WITH the words quoted above, Hughlings Jackson, who twenty years earlier had described² the focal motor convulsive seizures which have subsequently borne his name, not only reemphasized the sharply localized origins of such attacks but boldly faced the possibility of surgical therapy in such cases.

After Jackson's original pronouncements, Horsley³ and others had experimentally investigated the focal nature of convulsions and the physiologic effects of various cerebrosurgical procedures⁴. During the same period several surgeons carried out excisions of portions of the motor cortex because of focal epilepsy. The first was by Horsley⁵ in 1886 and he subsequently reported 2 additional cases, in 1890⁶. Keen,⁷

From the Department of Surgery, Vanderbilt University School of Medicine. Some of the data and several of the cases on which this paper is based were presented before the Society of Neurological Surgeons, Nashville April 18 1946.

¹ Jackson, J H. On Convulsive Seizures. The Lisleian Lectures, Brit. M. J. 1 703, 1890.

² Jackson, J H. Notes on the Physiology and Pathology of the Nervous System. M. Times & Gaz. 2 481 (Oct. 23) 1869, Study of Convulsions. St. Andrews's M. Grad. A. Tr. 3 162, 1870.

³ Horsley, V. The Brown Lectures. Epilepsy, Lancet 2 1211 (Dec. 25) 1886.

⁴ Horsley³ was apparently the first to apply the term 'jacksonian convulsions' to the local motor seizures described by Jackson.

⁵ Horsley, V. Remarks on Ten Consecutive Cases of Operations upon the Brain and Cranial Cavity to Illustrate the Details and Safety of the Method Employed. Brit. M. J. 1 863 (April 23) 1887.

(Footnotes continued on next page)

Nancrede⁸ and Lloyd and Deaver⁹ all reported cases in 1888. None of these cases was followed sufficiently long to justify conclusions regarding the convulsions, but it was observed in all cases that voluntary motion of considerable degree returned to the paralyzed parts. This was also true in Horsley's better known case of motor cortical excision for athetosis reported in 1909.¹⁰

In this connection, Gowers¹¹ wrote, in 1896, "If, indeed there is no evidence of removable disease, the excision of the centre, stimulation of which causes the movements with which the fits commence, may arrest them, and if the area excised is not very extensive, the loss of power it causes soon lessens to a moderate degree, as Horsley and others have abundantly proved."

As neurosurgery developed, the suggestions of Jackson, Gowers and Horsley were generally ignored, and it was not until 1935 that Sachs¹² reported excision of the motor cortex in 11 patients, 8 of whom suffered from jacksonian fits. In 1938, Furlow,¹³ from the same clinic, added 5 additional cases.

Foerster¹⁴ evidently removed the motor cortex in a number of patients but did not cite individual cases. Putnam¹⁵ and Bucy¹⁶ have excised portions of the motor cortex for various types of involuntary movements, and in 1 case reported by the latter¹⁷ the operation was

6 Horsley, V. Remarks on the Surgery of the Central Nervous System, Brit. M. J. 2 1286 (Dec. 6) 1890.

7 Keen, W. W. Three Successful Cases of Cerebral Surgery, Am. J. M. Sc. 96 329 (Oct.), 452 (Nov.) 1888.

8 Nancrede, C. B. Two Successful Cases of Brain Surgery, M. News 53 584 (Nov. 24) 1888.

9 Lloyd, J. H., and Deaver, J. B. A Case of Focal Epilepsy Successfully Treated by Trephining and Excision of the Motor Centres, Am. J. M. Sc. 96 477 (Nov.) 1888.

10 Horsley, V. The Limacre Lecture on the Function of the So-Called Motor Area of the Brain, Brit. M. J. 2 125, 1909.

11 Gowers, W. R. Manual for Diseases of the Nervous System, Philadelphia, P. Blakiston, Son & Co., 1896, vol. 2 p. 767.

12 Sachs, E. The Subpial Resection of the Cortex in the Treatment of Jacksonian Epilepsy (Horsley Operation) with Observations on Areas 4 and 6, Brain 58 492, 1935.

13 Furlow, L. T. Subpial Resection of the Cortex for Focal Epilepsy, J. A. M. A. 111 2092 (Dec. 3) 1938.

14 Foerster, O. Motorische Felder und Bahnen, in Bumke, O., and Foerster, O. Handbuch der Neurologie, Berlin, J. Springer, 1936, vol. 6 pp. 1-357.

15 Putnam, T. J. Treatment of Unilateral Paralysis Agitans by Section of the Lateral Pyramidal Tract, Arch. Neurol. & Psychiat. 44 950 (Nov.) 1940.

16 Bucy, P. C. Effects of Extirpation in Man, in The Precentral Motor Cortex, Urbana, Ill., University of Illinois Press, 1944, p. 355.

17 Bucy, P. C. Cortical Extirpation in the Treatment of Involuntary Movements, A Research Nerv. & Ment. Dis., Proc. 21 557, 1942.

performed for focal convulsions, with no recurrence of the attacks up to four years after operation

During the past ten years, one of us (C P) has performed partial excision of the motor cortex on 41 patients who suffered from jacksonian convulsions¹⁸ It is the purpose of this paper to present the clinical results in this series More detailed observations on the physiologic effects of cortical stimulation and of the operative procedure will be reported in another communication

CLINICAL MATERIAL

All patients in this series have had focal cortical convulsions, none has had a gross cicatrix or a space-occupying lesion and all have been subjected to partial excision of the motor cortex

The foci of origin of the seizures have been nearly equally distributed between the two sides, but attacks beginning in an upper extremity have predominated (table 1) This is not due to reluctance of the operator

TABLE 1—*Primary Focus of Attacks*

Right side of face	1	Left side of face	2
Right arm	19	Left arm	15
Right leg	2	Left leg	2

to remove the face or leg areas but to an actually greater frequency of occurrence of attacks which begin in the upper extremity in our experience It is true, however, that several patients whose attacks begin in the dominant side of the face (and have not been frequent or severe) have not been operated on

The duration of the history of seizures was less than two years in only 8 of the 41 cases and was greater than five years in 17 cases The frequency of attacks was naturally variable, but 17 patients had seizures which averaged not less than one per day No patient was subjected to operation unless the duration and frequency of the attacks and failure to control them or difficulty of control by anticonvulsant drugs were thought to justify the presumption that they would continue to occur indefinitely

Localizing electroencephalographic evidence corresponding to the pattern of the convulsions was present in many cases but lacking in others There was no significant roentgenographic localization in any case (plain stereoscopic exposures were made in all cases, and pneumoencephalograms in approximately half of them)¹⁹

¹⁸ Eliminated from the series presented before the Society of Neurological Surgeons have been 5 cases in which there were grossly visible although small and localized, scars Several more recent cases have not been followed long enough to be included

¹⁹ Obviously many roentgenographically demonstrable scars hematomas tumors and congenital lesions which produced jacksonian seizures are not included in this series

A severe preoperative paresis was present in only 1 patient in the series, but many patients had slight residual weakness in the parts primarily affected, particularly immediately after a series of severe seizures.

The patients were predominantly children or young adults. Eighteen were under 12 years of age, 20 were from 12 to 30 and only 3 were over 30. Seventeen were male and 24 were female.

TABLE 2—*Duration of Follow-Up*

Duration	Number of Cases
1 to 2 years	7
2 to 3 years	10
3 to 6 years	15
More than 6 years	9

All cases have been followed in the postoperative period more than one year and more than half of them more than three years (table 2).

OPERATIVE PROCEDURE

All operations were carried out with the patient under local anesthesia, except those on small children, which were done with the patient under anesthesia with ether given intratracheally. Even in the latter cases, results of electrical stimulation were satisfactory in all except 1 instance (to be cited).

The same type of operation was carried out in all cases. An osteoplastic flap, designed to expose the motor cortex on the affected side was reflected and the dura was incised in flap fashion, with the hinge of the flap toward the midline. The exposed cortex was inspected, palpated and sometimes explored with a ventricular cannula.

A map of the cortex was then made on sterilized cellophane, cortical markings being traced directly on the closely applied sheet of cellophane and points of subsequent stimulation being marked by numbers on the map with sterile pen and ink (fig. 1).

Electrical exploration was then carried out²⁰ by means of stimulation with a unipolar electrode employing a 60 cycle, 110 volt lighting current reduced by transformer to voltage of 0 to 8 volts. Stimulation was begun on the anterior lip of the central sulcus and was sometimes confined to this "strip." In many instances, however, more widespread electrical exploration was done. The desired area was localized in this manner in all cases but 1. On several occasions the patient's convulsions were reproduced by stimulation. In such instances a few drops of chloroform on gauze served to control the seizures promptly.

²⁰ Dr. Sam L. Clark and Dr. James Ward furnished the stimulating apparatus and made detailed and accurate observations and notes on the patients during stimulation.

When the desired area had been identified, subpial resection of the cortex was carried out (fig 2). The procedure was similar to the

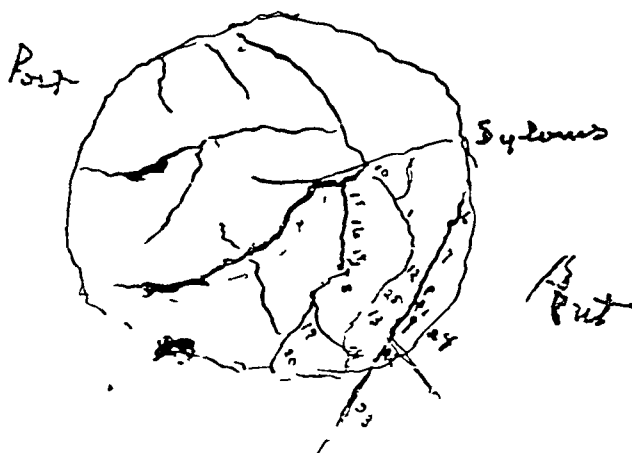


Fig 1—Photograph of cellophane map of the cerebral cortex. Numbers represent points of stimulation.

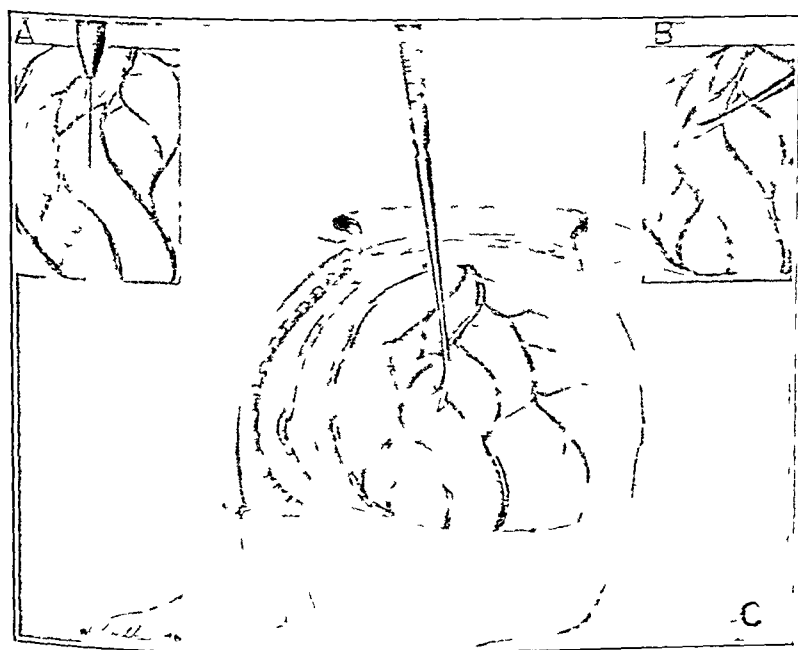


Fig 2—Subpial resection of the cortex. A, electro-surgical incision of the previously coagulated pia mater. B, reflection of the pia. C, removal of cortex to the depths of the sulcus by blunt dissection.

“Horsley operation” described by Sachs.¹² The pia mater in the center of the precentral convolution was coagulated longitudinally for the length

of the planned resection. This length usually extended slightly above and below the excitable area corresponding to the peripheral focus of origin of the patient's attacks. With the electrosurgical cutting current, the pia and superficial gray matter were incised. Resection of the cortex to the depth of the central sulcus was then carried out by blunt dissection, great care being taken to reach the pia of the anterior wall of the sulcus to its full depth. In most cases, the removal of tissue included, and was confined to, the precentral convolution for the variable superoinferior lengths dictated by the pattern of the patient's convulsions and the results of stimulation. Removal of tissue in this way was necessarily piecemeal and often interfered with satisfactory microscopic study (this is discussed in the following section). There was no doubt, however, regarding the complete removal of the entire anterior wall of the central sulcus (as well as the adjacent portion of the precentral gyrus) for the desired length in all cases (excepting the single case in which no response to stimulation was obtained).

In 6 cases (in which focal sensory phenomena had been prominently present in the convulsions), the portion of the postcentral gyrus corresponding to the extent of the precentral excision was also removed in the same manner, the rolandic vessels being left intact.

The procedure of subpial resection is a relatively bloodless one and was chosen as that best suited to the welfare of the patient. No significant operative difficulty was encountered in any case.

TABLE 3—*Results of Operation with Respect to Mortality*

Results	No of Cases Percentage	
Postoperative deaths	2	4.87
Late deaths	3	7.31
7 weeks pneumonia		
21 months status epilepticus		
5 years status epilepticus		
Alive today	36	87.8

The 2 operative deaths (table 3) which occurred in the series took place eight and nine days, respectively, after operation. The cause of death, as shown at necropsy, in the first was a pulmonary embolus, and in the second no complications of the operation were discovered and the cause of death is unknown.

GROSS AND MICROSCOPIC OBSERVATIONS

All cases in which there were gross cicatrices or space-consuming lesions have been eliminated from this series. At operation, the appearance of the brain was perfectly normal in 24 cases. In 17 there were visible arachnoidal thickening and grayish opacity or apparent shrinkage and atrophy of convolutions or both. These abnormalities were never confined to a single area, though on several occasions the operator

thought that they were most marked in the area subsequently proved to correspond with the focus of origin of the patient's attacks

Microscopically, the tissue removed was normal in all respects in 14 cases. In 25 cases there was a distinct increase in glial elements (without definite glial scar in any case) and in 2 cases there was recognizable fibrosis in addition to gliosis

From the standpoint of cortical architectonics, accurate determination of the extent of cortical excision was impossible because of the bit by bit method of removal of tissue. However, study of multiple sections of numerous blocks from each case, stained by the Nissl method, hematoxylin and eosin and other methods, has shown gigantopyramidal (Betz) cells in the majority of instances

There can be little doubt that the tissue removed in each instance included the corresponding portion of area 4. It seems highly probable, however, that the excised areas also included whatever varying portions of the premotor cortex happened to lie in the precentral gyrus

RESULTS OF STIMULATION

With the exception of a single case, the desired area of the motor cortex was located in all patients

However, in addition to the anatomic localization thus obtained, two additional phenomena were observed in a number of instances, which added weight to the presumption of a hypersensitive cortical focus of origin of the patients' seizures

The first was a differential hypersensitiveness in terms of voltage required to produce a motor response at the area in the motor cortex corresponding to the origin of the focal attacks. Thus, in a patient whose attacks began in the left hand, a current of 2 volts would produce (at a certain cortical point) motor responses in the left hand, whereas 4 or 5 volts might be necessary to induce responses (from their respective cortical areas) in the left leg or the left side of the face

The second significant type of observation was the exact reproduction of the patient's seizure by stimulation of the appropriate cortical point with a current which produced only conventional local motor responses (or none at all) from adjacent portions of the motor cortex. This phenomenon was described by Nancréde⁸ in 1888 and was observed in 12 of our cases

POSTOPERATIVE RESULTS PARALYTIC PHENOMENA

Immediately after operation, every patient (except the single one who failed to respond to stimulation²¹) showed a complete flaccid

²¹ This patient, a 3 year old child had excision of the area presumed to be the motor facial area. Following operation, there was only slight facial weakness for three weeks, but there has been no return of convulsions in fourteen months

paralysis of the affected part with absence of deep reflexes. In several instances of sharply localized attacks and correspondingly small areas of excision this paralysis was confined to movements of the hand alone but in most cases an entire extremity or side of the face was involved.

Hoffmann's sign, the sign of Babinski, forced grasping and other neurologic phenomena were variable in their appearance and will be discussed elsewhere. Spasticity accompanied by overactivity of the tendon reflexes did not develop in fewer than twelve days and in most cases, was not observed until the patient's first return visit after discharge from the hospital—usually four to eight weeks after operation. Thus the exact time of its appearance was often uncertain. The subsequent degree of these abnormalities tended to parallel the motor weakness and recovery therefrom.

Within eight to twenty days after operation, voluntary motor recovery began in all cases. Gain in strength and in facility of movement and diminution in spasticity continued gradually for six to twelve

TABLE 4—Results of Operation with Respect to Disability

Result	Number of Cases
No residual neurologic deficit	15
Mild residual weakness	17
Moderate residual weakness	3
Severe residual paralysis (present prior to operation)	1

months, but perceptible voluntary movements in all muscle groups had appeared in all patients in four to six weeks. In the upper extremity, flexor movements returned first and extension of the terminal phalanges of the fingers was the last movement to return. In the lower extremity, the calf muscles recovered before the anterior tibial group and extension of the toes was usually observed before flexion.

In only 1 patient (who had severe preoperative hemiparesis) has a marked degree of persistent weakness been observed. In 3 others moderate weakness of the affected extremity is apparently permanent. In 17 patients there is minor impairment of fine movements of the hand, slight spasticity of the fingers or a minor degree of weakness of the dorsiflexors of the foot. In the remaining 15 patients no demonstrable neurologic deficit is present. These patients play the piano, do needlework or perform comparable acts with the originally paralyzed muscles (table 4).

In the 6 patients who had postcentral (as well as precentral) cortical excisions, there was invariably a complaint of paresthesia ("numbness," "wooden arm," "rub my arm," "it feels like I'm going to have a spell") for three to ten days after operation. All 6 patients had diminution in (but not absence of) tactile and painful sensation in the affected extremity.

which has persisted in 3 and disappeared after several months in the other 3. Astereognosis and loss of position sense were observed for seven and ten days, respectively, in 2 patients.

POSTOPERATIVE RESULTS CONVULSIONS

All patients were given diphenylhydantoin sodium or phenobarbital for not less than one year after operation. Medication thereafter varied with the course of the individual patient.

The effects of the operation on the patients' convulsions are summarized in table 5. Eight patients (19.5 per cent) have had no seizures of any kind since operation. Of these, 2 had preoperative attacks several times daily, 3 had attacks more frequently than once weekly and 3 had attacks averaging two per month. The onset of attacks was two years or less prior to operation in 5 cases, but was more than seven years in the remaining 3. The ages of the patients were 18, 9, 18, 12, 19, 32, 8 and

TABLE 5—Results of Operation with Respect to Convulsions

Results	No of Cases	Percentage
No convulsions	8	19.5
More than 5 years	2	
More than 3 years	4	
More than 2 years	2	
Marked improvement	12	29.2
No attack past 5 years	3	
No attack past 3-5 years	1	
No attack past 1-3 years	2	
Infrequent attacks	6	
Improved	9	21.9
No improvement	8	19.5
Dead (with or without improvement)	5	12.1

22 years, respectively. These ages correspond approximately with the age distribution of the series as a whole. These 8 patients have returned to their normal occupation and consider themselves well.

Twelve patients (29.2 per cent) are classed as showing "marked improvement." Six of these had one or several seizures in the first postoperative week and have had none since. The remaining 6 are patients whose attacks occurred with great frequency prior to operation, but who have had only a few seizures at widely spaced intervals (greater than six months) since operation.

Nine patients (21.9 per cent) are classed as "improved" because of definite diminution in frequency and severity of attacks.

Eight patients (19.5 per cent) showed no sustained improvement but none of them were classified as worse.

Of the 3 patients who died at a later time, 1 expired at home of pneumonia seven weeks after operation having had no postoperative

convulsions²² A second had several severe postoperative attacks in a period of fifteen months, then had a symptom-free period of six months and finally died in status epilepticus twenty-one months after operation The third showed no postoperative improvement and died in a convulsion five years after operation

COMMENT

If one considers the distressing and disabling condition which is the subject of this paper, a condition usually considered to be irremediable, the results reported in our series must be regarded as highly encouraging A procedure which in itself produces little or no permanent disability and the operative mortality rate of which has been less than 5 per cent has resulted in apparent cure or great improvement in 48.7 per cent of cases and in a lesser degree of improvement in an additional 21.9 per cent of cases

Although all patients in our series had in common the occurrence of focal motor cortical seizures and the absence of space-consuming or grossly cicatricial lesions, there were several variable factors among them Thus, the causation of the disorder has been variable, when known, and frequently unknown Similarly, no microscopic abnormality was demonstrable in 14 cases, whereas the remainder showed variable degrees of glial proliferation and arachnoidal thickening Analysis of available data has failed to reveal any significant relationship between history of injury or of encephalitis and the microscopic observations

Further, neither of these factors can be statistically related to the effect of operation on the patients' convulsions

Because of the method of excision employed, the precise amount of motor cortex removed cannot be stated, nor can the likelihood of inclusion in the excision of small portions of area 6 be denied This renders evaluation of the postoperative neurologic picture difficult, and detailed discussion of this subject will be reserved for another report

That removal of a portion of the motor cortex could be followed by excellent return of motor function was known to Horsley, Gowers and others, as already stated, but most neurosurgeons have treated this area with a healthy respect and few have hitherto made deliberate surgical attack on it Thus Penfield and Erickson²³ stated in 1941, "The disability resulting from removal of motor arm area is so great that we have rarely touched the precentral gyrus and interference with the post-central gyrus is almost equally troublesome, because the hand becomes awkward and useless for delicate tasks" Our results show clearly, however, that such attack can be made with relative impunity,

²² This patient is *not* included in the "no convulsion" group

²³ Penfield, W., and Erickson, T. C. *Epilepsy and Cerebral Localization*, Springfield, Ill., Charles C. Thomas, Publisher, 1941

but the mechanism of the return of function after motor cortical removal is by no means established and cannot be discussed here

Our observations indicate that the occurrence of convulsions within the first few postoperative days is not necessarily of unfavorable prognostic significance. In 6 instances, such immediate postoperative seizures have been followed by complete freedom from attacks in the entire subsequent follow-up period, and in several other cases marked improvement has followed.

SUMMARY

In 41 patients with severe and frequent jacksonian convulsions but without space-consuming or gross cicatricial lesions, partial excision of the motor cortex has been carried out. No microscopic lesion was found in the tissue removed in 14 cases. Gliosis was present in the remainder.

There were 2 operative deaths. Gradual return of motor function with little or no disability occurred in all but 4 patients, who had moderate (3 patients) or severe (1 patient) hemiparesis.

Eight patients have been completely relieved of convulsions, 12 have shown pronounced improvement, 9 have been improved to a lesser degree, 8 have shown no improvement and 3 have subsequently died (1 of other cause).

It is believed that partial excision of the motor cortex has a place of real value in selected cases with focal motor convulsions.

NONDRAINAGE AND EARLY AMBULATION IN CASES OF PERFORATIVE APPENDICITIS

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THIS paper is a study of 15 cases of perforative appendicitis with peritonitis or abscess formation in which the appendix was removed, sulfathiazole was employed intraperitoneally, the incision was closed without drainage and spinal anesthesia and early ambulation were used. There were no deaths, a secondary intraperitoneal abscess requiring drainage occurred in 1 case. There were no other complications and no purulent wound infections. Penicillin was administered in the last 7 cases.

From this small series of cases the following conclusions have been deduced. Nondrainage in cases of perforative appendicitis with peritonitis is preferable to drainage. It is safe, and is desirable because it eliminates prolonged drainage and wound infection and minimizes the hazard of such postoperative sequelae as adhesions, hernia, fistula and obstruction. It shortens the stay in the hospital, saves dressings and bandages, lessens expense to the patient and lowers mortality. It is, moreover, impossible to drain the entire abdominal cavity.

The excellent results obtained with the intraperitoneal use of sulfathiazole over a period of five years confirm the experimental work of Throckmorton. He found that sulfathiazole is a specific against a large number of micro-organisms, that it is relatively innocuous to the peritoneum, that it has prolonged bacteriostatic effect and that it stimulates a local response similar to that in any other form of peritoneal medication.

Early ambulation in these cases of perforative appendicitis, despite ileus, peritonitis and fever, was found to be just as satisfactory and desirable as with other types of abdominal surgery. In like manner, the necessity for intravenous infusions, duodenal suction, catheterization and enemas was decreased.

Primary closure in cases of ruptured appendix is neither a new nor a radical procedure. Before the advent of the sulfonamide drugs or penicillin, several surgeons reported successful results with this method.

From the Jackson Clinic

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association,
Memphis, Tenn., Dec. 6, 1946.

Thus, Cottis and Ingham,¹ in 1935, reported a series of cases of localized and diffuse peritonitis, in 28 of which drainage was employed, with 9 deaths, and in 26 of which drainage was not employed, with 3 deaths, a mortality of 32.15 per cent in the cases with drainage and of 11.11 per cent in the cases without drainage. Cafritz² found that nondrainage resulted in less morbidity and less mortality, it minimized postoperative mechanical ileus, shortened the duration of illness, lessened the tendency to postoperative hernia, excluded the possibility of development of fistula and minimized the tendency to postoperative adhesions. In 1939 Pickell³ reported a series of 30 cases of spreading and generalized peritonitis, in only 1 of which a drain was used. There were 3 deaths.

In the same year Warren⁴ compared results in a series of 91 cases with drainage and 25 similar cases without drainage. He concluded that a drain was the most important factor in the causation of fistula. In the entire series there was not a single case, with or without drainage, in which the wound did not show some evidence of infection, in 17.5 per cent of cases with drainage and in 60 per cent without drainage there was some evidence of secondary abscess formation. The author then studied a group of 25 cases of intestinal obstruction in the Peter Bent Brigham Hospital, 15 with drainage and 10 without drainage. The mortality for the 15 cases with drainage was 18.3 per cent, and for the 10 cases without drainage, 17.6 per cent.

In 1939 Collins⁵ studied a series of 496 cases of perforated appendix with abscess formation in Los Angeles hospitals and concluded that spinal anesthesia was the safest of all types, resulting in a 12.6 per cent reduction in mortality over all other forms of anesthesia.

In 1944 Davison and Letton⁶ reported that with the intraperitoneal use of the sulfonamide drugs they had lessened the average stay of the patient in the hospital almost six days.

Obviously, it is possible to review the literature only briefly, but from these reports it is apparent that the mortality rate for the cases without drainage was lower than that for the cases in which drainage was employed. However, even in the cases without drainage the mortality rates were from 11 to 17 per cent.

1 Cottis, G. W., and Ingham, H. W. The Nondrainage Treatment of Peritonitis, *New York State J. Med.* **35** 49-55 (Jan. 15) 1935.

2 Cafritz, E. A. Nondrainage of the Peritoneal Cavity in Appendiceal Peritonitis. *J. A. M. A.* **108** 1315-1317 (April 17) 1937.

3 Pickell, F. W. Nondrainage in Complicated Appendicitis. Review of One Hundred and Nine Consecutive Cases. *Surgery* **5** 851-856 (June) 1939.

4 Warren, R. Primary Closure of Peritoneum in Acute Appendicitis with Perforation. Report of Twenty Cases. *Ann. Surg.* **110** 222-230 (Aug.) 1939.

5 Collins, D. C. Treatment of Complicated Acute Appendicitis with Particular Reference to Ochsner Method. *M. Rec.* **150** 127-129 (Aug. 16) 1930.

6 Davison, T. C., and Letton, A. H. The Modern Treatment of Perforating Appendicitis. *J. M. A. Georgia* **33** 1-6 (Jan.) 1944.

Although there are only 15 cases in the series I am reporting, in which no drainage was employed, there were no deaths and only 1 case of secondary abscess formation. The better results in this series must, I believe, be attributed to the use of chemotherapy. All wounds were closed as with a nonperforated appendix, and only a "mediplast" dressing (an elastic adhesive bandage with a central gauze compress) was applied. This brings up a point for discussion, for Meyer⁷ and Ochsner⁸ and their associates have stated that it is imperative that drainage of the peritoneal wall be employed. This has proved unnecessary with the method which my colleagues and I have used since 1941, when we began to use intraperitoneally approximately 10 Gm of sulfathiazole powder (not crystals) in $\frac{1}{2}$ pint (250 cc) of warm isotonic solution of sodium chloride. This is poured into the abdominal cavity, and the operating table is then tilted in all directions, so that the solution is carried from the diaphragm to the pelvis and from side to side. In closing the wound, no attempt is made to aspirate the solution, which is allowed to infiltrate the various layers. In addition, sulfathiazole powder is lightly dusted into all layers of the wound. The wound is closed with fine, interrupted and continuous, chromic surgical gut sutures. When we began to use early ambulation in these cases and in other cases of abdominal and pelvic surgery, fine tantulum wire was employed, but this has been given up. I am convinced that early ambulation, and not the type of incision or suture material, is the important factor in satisfactory wound healing. Employment of sulfathiazole powder dusted lightly into all incisions for the past five years has virtually eliminated infections of wounds. Yet theoretic conclusions and reports based on laboratory studies to the contrary continue to appear in the literature.

Similarly, surgeons who have for so many years kept their patients in bed long after a major surgical procedure continue to warn against and argue about the hazards of early ambulation. At the 1941 meeting of this association, in discussing the paper by Drs Counseller and McKinnon,⁹ I stated that patients can, and will, be got out of bed as early as the third or fourth day and that, as a consequence, the incidence of thrombophlebitis and embolism will decrease. This statement was criticized as radical by some members. On the contrary, I now believe it to be too conservative. Experience has shown that in most cases of abdominal, thyroid and breast surgery the patient does better by being

7 Meyer, K. A., Requarth, W. H., and Kozoll, D. D. Progress in the Treatment of Acute Appendicitis, *Am J Surg* 72: 830-840 (Dec.) 1946

8 Ochsner, A., and Johnston, J. H. Appendiceal Peritonitis, *Surgery* 17: 873-892 (June) 1945

9 Counseller, V. S., and McKinnon, D. A., Jr. Factors Influencing the Incidence of Postoperative Thrombophlebitis in Gynecologic Surgery, *Tr West S. A.*, 1941, pp 456-475

out of bed the first or second day unless he is in shock or threatened with hemorrhage. The only case in my service in the past two years in which an embolism occurred was a gynecologic case in which by mistake the patient was kept in bed three days. The use of heparin, dicumarol and oxygen enabled the patient to recover.

In 1920, when I was in the service of Dr. Henry Palmer, he impressed on me the harmful effects of keeping patients, particularly elderly ones, too long in bed. More and more I have come to appreciate the logic of his teaching. Early ambulation not only is conducive to speedy healing of the incision, by improving the circulation, but also reduces the necessity of catheterization, enemas, suction and intravenous therapy. Normal peristalsis is induced, the incidence of gas pains and ileus is minimized, and the patient is able to eat and enjoy food sooner. Atelectasis and pneumonia rarely occur any more.

One point concerning drainage is still debatable. Ochsner and Johnston⁸ stated that it is now generally agreed that unless there is a localized abscess peritoneal drainage not only does no good but actually may be harmful. But in the case of a localized abscess he continues to use drainage, although he does not do so in a case of localized peritonitis. He also packs the wound with gauze and does not suture the skin, as is the method advocated by Gamble. In 8 cases in the present series abscess had formed and the wound was closed successfully without drainage, obviously, however, this is too small a series on which to have definite conclusions. However, I shall present a composite study of the views of 150 members of the Western Surgical Association with regard to drainage and chemotherapy from statistics compiled during the past four weeks.

Dees¹⁰ probably was the first to use a sulfonamide drug intraperitoneally, and the Roosevelt Hospital group, in New York, popularized the method in 1941. They have always advocated the use of sulfanilamide locally. Early in our experience we discontinued the oral, subcutaneous and intravenous use of the sulfonamide compounds, believing the single large intraperitoneal dose to be the most effective.

When penicillin became available, it was employed in 30,000 unit doses every three hours, or in 300,000 unit doses in beeswax daily. Recently Crile¹¹ reported a series of 50 cases of proved peritonitis of appendical origin in which 100,000 units of penicillin was given intramuscularly every two hours for two to six days and but 1 death, from mesenteric thrombosis, occurred. In cases of spreading peritonitis the

¹⁰ Dees J. G. A Valuable Adjunct in Perforated Appendices. *Mississippi Doctor* 18:215-217 (Sept.) 1940.

¹¹ Crile G. Jr. Peritonitis of Appendiceal Origin Treated with Massive Doses of Penicillin. Report of Fifty Cases. *Surg. Gynec. & Obst.* 83:145-203 (Aug.) 1946.

infection was controlled with penicillin. In no case was it necessary to drain an intraperitoneal abscess, and there was no spontaneous drainage into the bowel.

This report may revolutionize the treatment of peritonitis resulting from appendical perforation. It was not obvious to us that the additional use of penicillin materially altered the progress in our cases, and it had no apparent effect in the case of secondary abscess. However, the maximum dose of penicillin employed in our series was 300,000 units in twenty-four hours, in contrast to 1,200,000 units used in Dr. Crile's series. If any members of the association have had an opportunity to use penicillin in these larger doses, it should be reported in the discussion.

The problem of anesthesia seems to be largely a question of one's preference, however, having routinely used spinal anesthesia in abdominal surgery since 1928, I feel that it has definitely decreased the incidence of complications and has been a factor in the absence of deaths in this series.

Meyer and associates,¹² in a review of cases of appendicitis at Cook County Hospital, stated that in cases of appendectomy without drainage the mortality rate was much lower than in similar cases with drainage, that chemotherapy is largely responsible for the lowering of the mortality rate, from 26.4 to 13.9 per cent, and that spinal anesthesia is the method of choice.

That the problem of appendicitis has been of great interest to the members of this association is evident from a review of the *Transactions*. From 1891 to 1945 eighteen papers on various phases of the subject were presented. All of them reflect a realization of the seriousness of the disease, the unwarranted loss of life and the need of better methods of dealing with the problem. In the minds of some, appendicitis might appear as a lowly subject because of its common occurrence, despite all recent advances, however, the latest available statistics indicate that more than 8,000 persons died of appendicitis in this country in 1943. These statistics, of course, do not include the numerous deaths resulting from intestinal obstruction and other postoperative complications long delayed.

As Black¹² pointed out in his excellent presentation at the 1940 meeting of this association, men do not write papers on subjects which are generally accepted as settled. He noted 1,200 articles on various phases of appendicitis published in the two years preceding his paper.

In a previous paper read before the association in 1931, Black¹³ presented an extensive statistical study on appendicitis compiled from the reports of 52 authors, covering the results of 1,500 surgeons working

¹² Black, C. E. Appendicitis, *Tr. West. S. A.* 1940, pp. 301-320.

¹³ Black, C. E. Appendicitis Statistics, *Tr. West. S. A.* 1931, pp. 423-444.

at 150 hospitals. For the cases of suppurative appendicitis the combined mortality rate was 7.87 per cent, for the cases of gangrenous appendicitis, 8.73 per cent, and for the cases of spreading peritonitis 21.19 per cent. The basic average mortality for all cases was 5.59 per cent. In discussing the number of days in the hospital following operation, Black cited a leading surgeon of his day, John Deaver, who mentioned periods varying from one to fifteen weeks.

We have come a long way from those figures of 1931, yet, unlike most surgical conditions, the mortality rate for appendicitis in this country rose steadily from 9.7 per cent per hundred thousand of population, in 1900, to 12.8 per cent, in 1936. Despite improved methods of medical teaching, developments in anesthesia, perfection of operative teamwork

TABLE 1—*Clinical Data on Fifteen Patients with Perforative Appendicitis Treated with Nondrains and Early Ambulation*

Number of patients (8 males and 7 females)	15
Average age, years	35
Average stay in bed, days	2
Average stay in hospital, days	12
Secondary abscess	1
Purulent wound infection	1

TABLE 2—*Value of Intraperitoneal Use of Sulfathiazole and Penicillin in Fifteen Cases of Perforative Appendicitis*

Chemotherapy used intraperitoneally	15
Sulfathiazole, Gm. in $\frac{1}{2}$ pint of warm saline solution	10
Sulfathiazole used generally	3
Penicillin used generally *	7

* Average dose of penicillin, 800,000 units in twenty-four hours.

better and quicker methods of transportation and thousands of articles and lectures on the subject, both for the layman and for the members of the medical profession, 2 persons died of appendicitis every hour until the introduction of the sulfonamide drugs and of penicillin. These drugs have effected a great reduction in the death rate, from about 17,000 persons a year to approximately one-half that number. Yet half a million deaths from perforative appendicitis have occurred in this country in the past thirty years. The present death rate is still too high, if in all cases operation could be performed before perforation had occurred fully 98 per cent of the patients would recover.

In tables 1 and 2 the results of treatment in this series of cases are summarized.

Finally, a composite study of the views of 150 members of the Western Surgical Association on the principal points discussed in this

paper, namely, drainage and chemotherapy, is presented. When one considers the vast and important area in which the surgeons of this organization reside, extending, as it does, from Washington and Winnipeg, in the North, to Texas and Tennessee, in the South, and from Ohio and Michigan, in the East, to California, in the West, the influence of its members on the surgical decisions of others is of great moment.

One cannot say there is any uniformity of agreement on these important surgical considerations, or even that the views of the majority are necessarily correct. The ideas that I have expressed in this paper are largely those of the minority. I feel, however, that there is a growing tendency to support these views, namely, the value of nondrainage and local chemotherapy.

Replies to the questionnaire were received from 173 members, 23 were surgeons specializing in other fields or members who are no longer active. Thus, the replies of 150 were available for this study. Eighty-one members stated that they employed drainage, 38, that they do not use drainage, 17, that they rarely use drainage, 9, that they drain only if an abscess is present, and 5, that they drain only to the peritoneal wall. Sixty-nine are therefore opposed to drainage. Opinion, therefore, is fairly evenly divided on this subject. Several said, however, that they are beginning to abandon drainage.

As to the type of drain used, 76 stated that they favor the Penrose type, 12 the cigaret type, 14 a rubber tissue and 7 a rubber tube. Forty-two expressed no opinion.

Ninety stated that they favor the use of a sulfonamide drug within the peritoneal cavity and 60 that they oppose it, 47 use sulfanilamide, 35 sulfathiazole, 9 sulfadiazine and 1 succinylsulfathiazole. In addition to the local use in the peritoneal cavity, 93 stated that they favor the use of a sulfonamide drug by other methods and 43 that they oppose it, and 26 expressed no opinion.

Only 13 stated that they use penicillin within the peritoneal cavity, 137 had had no experience with this method. However, 119 were using penicillin by other methods, 26 expressed no opinion on this point, and 5 were using streptomycin.

REPORT OF SIX ILLUSTRATIVE CASES

CASE 1—A man aged 33 probably had rupture of the appendix twenty-four hours before operation. A right rectus incision revealed a retrocecal, ruptured appendix with several ounces of pus and no walling off. Appendectomy was performed, base first. Twelve grams of sulfathiazole in isotonic solution of sodium chloride was used as a lavage in the peritoneal cavity. The patient was out of bed in twenty-four hours and walking to the toilet in forty-eight hours. Except for a slight serous discharge for two days, the wound healed perfectly, and the patient was dismissed on the twelfth day.

CASE 2—A woman aged 28 had a gangrenous, perforated appendix with localized peritonitis. A pararectus incision was used. The appendix was about four times normal size with perforation near the tip and about 5 ounces (150 cc.) of foul pus. The pus was aspirated, and 10 Gm of sulfathiazole in isotonic solution of sodium chloride was introduced. The patient was out of bed on the second day. The incision healed primarily, and she left the hospital on the ninth day after operation.

CASE 3—A man aged 50 had a gangrenous appendix that had sloughed off at the base, and five interrupted silk sutures were required to close the perforation of the cecum. A pararectus incision was used. Ten grams of sulfathiazole in isotonic solution of sodium chloride was used as a lavage in the peritoneal cavity after aspiration of pus from the localized area of peritonitis. There was a slight sero-sanguineous discharge. The patient was discharged on the tenth day.

CASE 4—A woman aged 53 had been ill ten days. A diagnosis was made of appendical abscess and obesity, she weighed 201 pounds (91.2 Kg). This case presented an extremely difficult problem. A pararectus incision was used. The cecum and ascending colon were fixed in the region of the sigmoid, where a large appendical abscess was located. The appendix had sloughed off, and there were free fecaliths. The cecum was freed and restored to its normal location. The remnants of the appendix were removed. Because of the abnormal location of the abscess, there was much soiling of the lower part of the abdomen and the pelvis. Sulfathiazole was used as usual, and the abdomen was closed without drainage. Despite the obesity, only an elastic adhesive bandage with a gauze compress was applied and the patient was up on the second day. However, duodenal suction and intravenous therapy had to be continued four days because of slight ileus. The wound healed primarily. The patient was discharged on the sixteenth day. Home conditions were such that she could not be discharged sooner.

CASE 5—A man aged 55 probably had rupture of the appendix two days before operation, while he was driving from Chicago. A pararectus incision revealed a large, appendical abscess with almost complete obstruction of the bowel. The appendix had sloughed at the base, and free fecaliths were present. He was treated in the usual manner. Despite some degree of ileus and a temperature of 102 F, the patient was out of bed on the third day. Recovery was uneventful.

CASE 6—A man aged 46 had a retrocecal appendical abscess of about one week's duration. About 3 ounces (90 cc) of pus was aspirated, there were free fecaliths and a sloughing, gangrenous appendix with a slight perforation of the cecum. The patient received the usual treatment and penicillin therapy. Fever and some ileus prolonged recovery. The wound healed primarily, and he was discharged on the eighteenth day.

SUMMARY

A study is presented of 15 cases of perforated appendicitis with peritonitis or abscess formation in which the wound was closed without drainage.

The peritoneal cavity was lavaged in all cases with isotonic solution of sodium chloride containing approximately 10 Gm of sulfathiazole.

There was 1 case of secondary abscess requiring drainage, otherwise there were no complications and no deaths.

Spinal anesthesia and early ambulation were used in all cases

Penicillin, the dose not to exceed 300,000 units in twenty-four hours, has been used since it became available. Because successful results were obtained before its use, it is difficult to evaluate the worth of this drug. Possibly in much larger doses it may prove very efficacious.

The advantages of nondrainage, of chemotherapy and of early ambulation over methods formerly employed are evident.

A composite study of the opinions of 150 members of the Western Surgical Association on the problems of drainage and chemotherapy in cases of perforative appendicitis is presented.

This study shows that 81 members employ and 38 do not employ drainage, 18 rarely use a drain, 9 drain only if an abscess is present and 5 drain only to the peritoneal wall.

Ninety use a sulfonamide drug intraperitoneally, 60 oppose its use, 47 use sulfanilamide, 34, sulfathiazole, 9, sulfadiazine, and 1 succinyl-sulfathiazole.

Only 13 use penicillin intraperitoneally, but 119 use it in other ways, 5 use streptomycin.

DISCUSSION

DR ROBERT L. SANDERS, Memphis, Tenn.: I feel that I should not take the floor again, though it is a pleasure to discuss Dr. Jackson's paper. He has brought up a good question.

All are familiar with Lawson Tait's statement, issued many years ago, "When in doubt, drain." Today, most surgeons reverse this. "When in doubt, don't drain." And rightly so in many cases, especially the type in which drainage was used formerly. For example, in removing a gallbladder, it is now known—that it seldom matters if one omits drains. A perforated appendix does not present the same situation; however, the cecum is full of virulent organisms, and bacterial peritonitis is far more likely to develop—in fact, is already present. I have made enough mistakes to be afraid to take a chance that a patient with a ruptured appendix will be able to resist the onslaught of so many of these organisms without the assistance of drains. The sulfonamide compounds are fine, but I do not trust them alone. Moreover, if one sprinkles a solution of sulfathiazole about the abdominal cavity, one is likely to scatter living organisms as well.

One should keep an open mind on this subject, but for the time being I shall confine the use of sulfathiazole to the infected area and shall continue to put in a drain or two.

DR CUTHBERT POWELL, Denver: It is gratifying to me to see that Dr. Jackson has the courage to advocate closing the abdomen without drainage. It is also gratifying to me that he did not get the spanking I received, more than thirty years ago, before the first World War, in a paper which I read in Minneapolis before this society advocating nondrainage of the peritoneal cavity and showing that the peritoneal cavity could not be drained. I was spanked, and spanked properly. In fact, one of the older members got up and I was fearful that he would have a cerebral hemorrhage. He said that any member of this society who would advocate such treatment did not deserve membership in the society.

I am still here, and I agree with Dr Jackson that one cannot drain the peritoneal cavity. I started with nondrainage in gynecologic work, in cases of ruptured tubes and pus in the pelvis, and later treated appendicitis in the same way. During the war, I caught up with my good friend Dr Leighton of St Louis in an Army hospital, and he took me right up to operate on a man with appendicitis. I opened the abdomen and found an acute gangrenous appendix with localized peritonitis. I started to sew up the wound. Leighton was watching me and as I was putting in the sutures, he said 'Well, aren't you going to put in a drain?' I said 'If I do he will die.' He said, 'If you don't he will die.'

I did not use a drain and the man did not die.

DR GORDON S FAHRNI, Winnipeg, Manitoba, Canada. I am glad that Dr Jackson has brought up the subject of early rising after an abdominal operation.

Few of us, I am sure, will question the statement that the integration of the principles of physical medicine with the postoperative management of patients has developed all too slowly.

Deep breathing exercises with planned movements of arms and legs ventilate the lungs, maintain muscular tone and stimulate the circulation, particularly the venous return. The simple regimen may be carried out easily with almost all bed patients who, for one reason or another, are unable to get out of bed or whose surgeons are apprehensive or disagree with the practice of early rising when possible.

The more ambitious practice of getting patients out of bed for short periods the first day or so after operation and increasing the ambulatory period each day is still more controversial. Nevertheless, surgical opinion on this continent in favor of early rising after abdominal operations is growing stronger and more widespread.

The patient is usually a bit apprehensive about getting out of bed the first or second day after an abdominal operation. A tactful nurse assists him to the sitting posture while the legs are rolled out, as the feet touch the floor, the patient's confidence returns, and each day thereafter his enthusiasm increases. This practice gives a sense of well-being that is most gratifying to the surgeon and the patient's convalescence seems much more rapid. The common criticism is that wound healing may be retarded, predisposing to disruption of the wound or incisional hernia. The observations of many surgeons of considerable experience do not support this view.

Some of the more prominent benefits are the lowered incidence of pulmonary complications, such as atelectasis; the comparative freedom from ileus and the speeding up of the venous blood return which lessens the incidence of venous thrombosis and embolism. The less tangible benefits such as a sense of well-being and the shortening of convalescence, are striking.

Each great war has taught much in the care of wounds, not the least of which has been an added appreciation of the value of integrating the principles of physical medicine with the surgical care of patients, as demonstrated particularly in World War II.

Before the close of the late war, all Canadian army hospitals, both at home and abroad had their staffs of physical training instructors and the nurses participated in the plan. It can be truly said that the surgeons of the Army, Navy and Air Force became alert to the benefits of physical medicine, some going to the point of getting patients who had had abdominal operations out of bed the first or second day. It is my feeling that the development of this aspect of surgery in civilian hospitals has been backward and I welcome this opportunity to speak of

the subject before the members and guests of this association, in the hope of stimulating greater interest in the application of physical medicine to surgery.

DR JAMES JACKSON, Madison, Wis. I am Arnold's older brother, and if there is any spanking to be done it should be up to me to do it. Anyhow, as soon as I have made my remarks, I am leaving for the hill country in Arkansas to hunt quail, and he will have a difficult time in finding me.

All the Jackson brothers are individuals, and they never saw eye to eye on all subjects. Arnold got his early surgical training at Rochester, under careful supervision. Dr. Bob Sanders and I, on the other hand, got much of our early training operating in a farmhouse, on a kitchen table, boiling our instruments on the kitchen stove. When we removed a gangrenous ruptured appendix with abscess formation, we cleaned out the abscess and left a small drain down to the cavity. If there was pus in the pelvis, we inserted a cigaret drain down to the bottom of the pelvis. I continue to use this procedure today.

As to the question of flooding the peritoneal cavity with a solution of a drug such as one of sulfathiazole, there may have been a little misunderstanding as to the type of case in which Arnold meant to use this measure. He was referring to cases of generalized peritonitis, in which the pus has already spread to most of the abdomen, and not to a localized pocket. In the old days, when my brother, Dr. Reginald, or I had one of these cases, we used to flush out the peritoneal cavity with a quantity of saline solution, tilting the table and in that way diluting the pus and doing a good job of washing out the cavity. Miraculously, some of our patients got well. Of course, this would not be done with a localized abscess.

Arnold uses a drain in a case of clean gallbladder but closes up the wound in cases of abscessed appendix. I have done some 500 cholecystectomies without putting in a drain, but I usually use a drain in a case of appendical abscess.

I agree with everything that Arnold said about spinal anesthesia and early ambulation.

DR ARNOLD S. JACKSON. I can see that this discussion is rapidly degenerating into a family feud. A neighbor just leaned over and said "How old is Jim?" I said, "Oh, about 64. He is old enough to know better, anyway."

I selected this title because it has seemed to me that recently our meetings are getting pretty tame. We lack the gnashing of teeth and the pulling of hair we used to have with good old Leonard Freeman, Donald McKraig, Jabez Jackson and others, who used to make our discussions really worth while. I do not have any apologies for my subject, and I thank Bob Sanders for his excellent discussion. I purposely picked out Bob. I knew his views were the opposite of mine and that they would represent the opinions of the majority. However, the views of the majority cannot always be correct, and the fact that the questionnaire showed that opinion on the question of drainage is pretty evenly divided is something for every one to consider.

As for Bob, he is one of my best friends, as he has said, a few years ago Bob came up North to see how we were doing this operation. I tried to sell him on the idea of spinal anesthesia, but it was no use. Those of you who were at the meeting yesterday heard Bob say, "Well, spinal anesthesia is pretty fine, I am using it." So Bob will change his ways. Give him time!

(Slide) Jim cleared up one point in the treatment of the localized abscess. I did not mean to imply that the peritoneal cavity is flooded with staphylococci and other dangerous organisms. In cases of localized abscess, sulfathiazole is applied locally, but in the cases of peritonitis the entire peritoneal cavity is

irrigated with 12 Gm of the drug in saline solution. No one mentioned the use of very large doses of penicillin, but I noticed that the last group of letters I received were influenced by the recent article of Crile's on this point.

The only way to ascertain the facts is to try this method and see for yourself. I do not want any more of those dirty, purulent wounds that used to take so long to dress and care for. Nondrainage eliminates that sequela, as well as many others.

You all agree that Al Ochsner is a pretty good surgeon. He says that drainage of the peritoneal cavity for peritonitis not only does no good, but actually may be harmful. All highly respect the opinion of Karl Meyer, and he does not drain the peritoneal cavity in cases of peritonitis.

ISOLATED PARALYSIS OF THE SERRATUS MAGNUS FOLLOWING SURGICAL PROCEDURES

Report of a Case

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PARALYSIS of the serratus magnus muscle following surgical treatment probably occurs more frequently than is usually suspected. Cotton and Allen¹ reported 30 cases of peripheral paralysis in a review of the literature up to 1903. No other cases appeared in the literature until 1926, when Thorek² cited a case which he saw that year. The scarcity of reports since 1926 is remarkable.

Of the muscles supplied by the brachial plexus, the serratus magnus, by its anatomy and nerve supply, is most logically susceptible to isolated paralysis. The muscle is generally described as being formed of three parts. The upper part originates from the first two ribs and from a fibrous arch uniting these two attachments, and is inserted on the costal surface of the scapula near its medial angle. The middle part arises from the second, third and sometimes the fourth ribs, and spreads out into a thin sheet which is inserted along the vertebral border of the scapula. The lower part, which is the strongest, takes its origin by digitations from the fourth to the eighth or ninth rib and is inserted on the costal surface of the scapula near its inferior angle.

The long thoracic nerve, on which the serratus magnus muscle is almost entirely dependent for its innervation, was described by Morris³ as arising from the fifth, sixth and seventh cervical nerves. Horowitz and Tocantins⁴ found that the eighth cervical nerve also takes a part in the formation of the long thoracic nerve in some cases. The nerve trunk passes dorsal to the clavicle at the junction of its middle and outer thirds, then downward and laterally beneath the brachial plexus.

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1 Cotton F. J., and Allen, S. W. Brachial Paralysis, Postnarcotic, *Boston M & S J* 148:499 (May 7) 1903.

2 Thorek, M. Compression Paralysis of the Long Thoracic Nerve Following an Abdominal Operation, *Am J Surg* 40:26 (Feb) 1926.

3 Morris, H. Human Anatomy, Philadelphia, P. Blakiston's Son & Co., 1933.

4 Horowitz, M. T., and Tocantins, L. M. Anatomical Study of the Role of the Long Thoracic Nerve and the Related Scapular Bursae in the Pathogenesis of Local Paralysis of the Serratus Anterior, *Anat Rec* 71:375 (Aug 25) 1938.

and lateral to the axillary vessels and extends beneath the scapula and along the anterior border of the latissimus dorsi. Twigs are furnished to the superior portion of the serratus magnus by the two upper roots as it runs along the axillary border of that muscle and farther down the nerve supplies each digitation of the serratus magnus muscle.

In spite of these factors which appear to favor limitation of a paralysis to the serratus magnus, reports of such cases are rare as compared with the number of cases of paralysis affecting the entire brachial plexus. Especially rare is the appearance of isolated paralysis of the serratus magnus following operation, as I have found only 8 cases in the literature.

The etiologic factors most commonly mentioned are infection and trauma, the latter including overexertion, working with the arm above the head, carrying heavy weights and direct blows to the muscle or the nerve. Causes less often ascribed include exposure to cold, compression of the nerve roots by osteoarthritic deposits in the intervertebral foramina, inflammation of the subcoracoid and subscapular bursas, pressure by a cervical rib, toxic neuritis produced by the anesthetic and compression of the nerve as it passes through the scalenus medius muscle. Berkheiser and Shapiro⁵ stated the belief that concussion is the etiologic factor. Horowitz and Tocantins⁶ expressed the opinion that morphologic variations in the formation and distribution of the long thoracic nerve are influential and explain why identical traumas in different persons only infrequently result in this type of lesion. Brickner⁷ cited Verhoogen and Casse that a specific action of the anesthetic (chloroform) might be a causative factor in the production of a toxic neuritis, but this opinion is refuted by the experience of other observers.

Cotton and Allen¹ ascribed the paralysis solely to abduction of the arms drawn up over the head during anesthesia. Brickner,⁷ furthermore, cited Sehwald as stating that paralysis of the long thoracic nerve occurs by bruising of the brachial plexus between the clavicle and scalenus medius after operation in those cases in which the arm is hyperabducted.

Ellis⁸ concluded in his report that paralysis of the serratus magnus is much commoner in men than in women. Mullen⁹ stated that injuries

⁵ Berkheiser, E. J., and Shapiro, F. Alar Scapula, *J. A. M. A.* **108** 1790 (May 22) 1937.

⁶ Horowitz, M. T. and Tocantins, L. M. Isolated Paralysis of the Serratus Anterior Muscle, *J. Bone & Joint Surg.* **20** 720 (July) 1938.

⁷ Brickner, W. Peripheral "Anesthesia Paralysis." Report of Unusual Case of Bilateral Paralysis Occurring During Narcosis, *New York M. J.* **73** 722 (April 27) 1901.

⁸ Ellis, J. D. Delayed Traumatic Serratus Paralysis, *Arch. Neurol. & Psychiat.* **22** 1233 (Dec.) 1929.

⁹ Mullen, T. F. Safeguarding the Unconscious Operative Patient. *We. Surg.* **46** 678 (Dec.) 1939.

of the brachial plexus during operation are much commoner in women and usually follow some pelvic operation

At this time I should like to present a case of postoperative paralysis of the serratus magnus muscle, which responded successfully to treatment

REPORT OF A CASE

A young white woman in good physical condition was operated on under nitrous-oxide-oxygen-ether anesthesia, the McKesson machine being used. The operation consisted of appendectomy, uterine suspension, myomectomy and ligation of varicosities in the broad ligaments. The patient was placed in a 35 degree Trendelenburg position and supported by shoulder braces covered with rubber pads. The operation required one hour. The patient was awake within forty minutes after returning to her room. Two days after the operation, the patient *first complained of pain in her left shoulder*. On the seventh postoperative day, she awakened suddenly in the morning with a severe pain in her right arm. The next day she felt sore across her shoulders, but had no complaints referable to the arm. Ten days after the operation the right arm was sore, and the pain became severe two days later. At this time a hot pad was applied to the arm and oil rubs were given, with some relief. The patient was discharged on the thirteenth day after the operation with no complaint except a soreness of the right arm. One week later she noticed a deformity of the right shoulder region and returned for examination. During this examination, tenderness was noted anterior to the trapezius muscle and over the brachial plexus and a pronounced deformity of the right scapula. A diagnosis of winged scapula was made. Roentgenograms of bony structure revealed no abnormality. The patient received galvanic interrupted treatment of 1 to 2 amperes over the course of the long thoracic nerve lasting for five minutes, and therapy with infra-red rays and massage twice a week for approximately a year. At this time the condition has cleared up and a slight deformity is present. She is able to move her arm without discomfort.

The action of the serratus magnus muscle is to hold the scapula against the thorax and to draw it forward and laterally, by its highly developed inferior portion it rotates the bone so as to raise the point of the shoulder. It is of special importance in abduction of the arm and also aids to a slight extent in forced respiration. From these facts may be inferred the signs and symptoms of paralysis of the serratus magnus muscle. The patient is unable to raise the arm above the horizontal, and when he attempts to do this the median border of the scapula approaches the vertebral column. When the arm is held horizontally forward, the median border and the inferior angle of the scapula are removed from the thorax and the scapula stands off like a wing, this leaves between the scapula and the chest wall an excavation into which the entire hand may be introduced. There is weakness of the arm and the patient is unable to cross the arms anteriorly. There is also difficulty in performing pushing movements or exerting pressure.

The onset of paralysis is often preceded by sudden severe pain in the supraclavicular fossa or shoulder, radiating to ear, occiput, scapular region or arm, which may persist

Treatment of isolated paralysis of the serratus magnus muscle is according to the following plan 1 Focal infection, postural compression and occupational factors must be treated or eliminated Treatment includes braces, physical therapy, massage, electrical stimulation and guided exercises Slow surging sinusoidal current is applied so that only three complete phases of current stimulate the muscle daily 2 The arm is immobilized, the elbow being brought sharply across the chest with the forearm flexed and supinated 3 There is operative intervention by transplantation of the latissimus dorsi over the inferior angle of the scapula or transplantation of the clavicular origin of the pectoralis to the serratus magnus or the axillary border of the scapula

Prognosis is dependent on the degree of injury sustained Potts¹⁰ stated that prognosis for recovery was bad Most authors, however, have expressed the view that complete recovery is the usual outcome, but it requires from three months to a year

Prevention of postoperative paralysis is an important problem The anesthesiologist should see that the patient is made as comfortable as possible before rendering him unconscious This is accomplished by adjusting the arms properly at the patient's side, not allowing them to hang over the side of the table When the Trendelenburg position is to be assumed the shoulder rests should be adjusted laterally and away from the brachial plexus They should be properly padded so that they do not cause compression on the nerves Removing the unconscious patient from the operating table to the transportation cart and from there into bed requires diligent care and handling The neck should not be hyperextended during the moving nor should the arms be twisted in any manner whatever, as traction on the arms may cause tearing of nerves from the brachial plexus

The beginner in anesthesia should not be overzealous in his attempts to prevent the jaw from dropping by placing his fingers too firmly along the neck to give a strong brace, by doing so one or more of the fingers may press on the fifth, sixth and seventh cervical nerves near their exit between the scaleni, and, as is frequently the case, the head is violently rotated to one side and the nerve or nerves may be compressed between the fingers and the vertebrae

¹⁰ Potts, C S Isolated Paralysis of the Serratus Magnus Report of a Case, Arch Neurol & Psychiat 20 184 (July) 1928

PROGRESS IN ORTHOPEDIC SURGERY FOR 1945

A Review Prepared by an Editorial Board of the American Academy
of Orthopaedic Surgeons

XV FRACTURE DEFORMITIES

Prepared by

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(Continued from Page 612)

Principles—Smillie⁵⁷⁸ introduces his discussion of the stiff knee in fracture of the femoral shaft with a comment on the complex development of this joint. He attributes stiffness to adhesions in the joint, in the capsule or in the quadriceps, and states that powerful traction is the most important contributory factor. He condemns the use of skeletal traction for reduction, feeling that it should really be used only for maintaining reduction. He does not approve the use of skeletal traction for more than three weeks. If traction is absolutely necessary through the condyles he prefers a Steinmann pin to a Kirschner wire because it causes less reaction and because it is driven in and fits tighter. Actually he prefers skeletal traction through the upper part of the tibia. [ED. NOTE—Even the Steinmann pin should have a drill point of a cutting or "bayonet" type and should be drilled. The superiority of pins over wires in regard to reaction is not confirmed by my personal observations.] His points on surgical approach, fixation material and methods of grafting are well stated. [ED. NOTE—On page 321 he states "only non-toxic stainless steel should be used," and on page 322, "better to make the decision to carry out insertion of vitallium plate." Stainless steel and vitallium are quite different in composition and physical properties and obviously should not be mixed.] A supracondylar fracture he reduces manually and holds by 5 to 10 pounds (2.3 to 4.5 Kg.) skeletal traction through the tibial tubercle with angle of the Braun splint at the fracture site instead of at the knee. He changes to cutaneous traction and Thomas splint in eight weeks and makes an excellent point of keeping the knee straight for early exercise of the quadriceps. Fractures in the midshaft also are reduced manually and held by 5 to 10 pounds of cutaneous traction. If this is unsuccessful open reduction should be performed in a week. [ED. NOTE (L. D. B.)—One of the editors feels that there is seldom need for open reduction of fractures of the midshaft of the femur. This

578 Smillie, I. S. The Problem of the Stiff Knee Joint in Fracture of the Shaft of the Femur, *Edinburgh M. J.* 52: 317-328 (Sept.) 1945

bone has remarkable reparative ability] He prefers open reduction for displaced fractures of the upper third of the femur. He discusses rehabilitation measures manipulation and surgical treatment for release of adhesions in and above the joint [ED NOTE—This is an excellent article on the subject]

Greenberg and Mohamed⁵⁷⁹ endeavored to delay healing in the fractured fibula of rats by partial constriction of the femoral artery, using the normal side for control. The breaking strength was found to be from five to ten times greater on the normal side after intervals of from six to thirty days. Dextrose-1-phosphate administered subcutaneously had no favorable effect on healing the fractures as compared to inorganic phosphate, which was used as a control.

Habbe and Wright⁵⁸⁰ emphasize the importance of careful diagnosis, especially when the presence of a fracture may be overlooked because of more serious injuries elsewhere. While fractures may be missed in any region, particular attention is called to the carpal navicular fractures and fractures of ribs and vertebrae. [ED NOTE—This article reaffirms well known principles]

Harmon⁵⁸¹ describes a posterolateral approach to the tibia and the fibula. This offers a wide exposure of the middle three fifths of the tibia suitable for bone grafting and for synostosis operation. [ED NOTE—This brief article is well illustrated and is an excellent description of an incision which is valuable in selected cases]

Webster⁵⁸² reports on the treatment of scars following war injuries of the leg. Skin-grafting methods include (1) double end sliding flap (2) single end local sliding flap, (3) direct pedicle flap from the other leg—"delayed" shifting of the flap is not considered necessary in the latter, and (4) intermediate flaps from a distance. [ED NOTE—This article is a brief statement of methods of skin grafting for lesions on the leg]

Somervell⁵⁸³ discusses the treatment of old neglected fractures which he encountered in missionary work in India over a period of twenty-five years. He summarizes briefly the physiology of formation of callus and the principles of immobilization. For a shortened ulna he recom-

579 Greenberg, D. M. and Mohamed, M. S. Effect of Lowered Blood Supply and of Glucose-1-Phosphate on Healing of Fractures. *Proc. Soc. Exper. Biol. & Med.* **57** 203-205 (Nov.) 1944.

580 Habbe, J. E., and Wright, H. H. Evidence of Old Forgotten or Previously Undiagnosed Fractures. *Radiology* **43** 531-547 (Dec.) 1944.

581 Harmon, P. H. A Simplified Approach to the Posterior Tibia for Bone Grafting and Fibular Transference. *J. Bone & Joint Surg.* **27** 496-498 (July) 1945.

582 Webster, G. V. The Scar Problem in Compound Injuries of Lower Leg. *Stanford M. Bull.* **3** 109-113 (Aug.) 1945.

583 Somervell, T. H. Malunited and Ununited Fracture. *J. Chiropractic* **11** 20-27-30 (March) 1945.

mends excision of the radial head to relieve pressure on the capitellum. For a shortened radius he step cuts the ulna and shortens it [ED NOTE—When the inferior radioulnar joint is disturbed, resection of the lower end is preferred]. When the fibula is disproportionately long after fracture of the tibia only, the former is shortened [ED NOTE—This article is a brief discussion of impressions and includes several reports of cases on a few related conditions].

Nonunion—Boyd⁵⁸⁴ reports over 90 per cent successful results in 575 cases of bone graft for nonunion of the shaft of long bones. He reviews the important diagnostic points as well as the operative technic using massive onlay grafts fixed with four or more metal screws. He does not recommend grafting until several months after infection is cured. In applying the graft, the endosteal bone is cut from the cortex of the graft [ED NOTE—Since the endosteal bone is then added it would appear desirable to leave it on the graft except when removal is necessary for proper fit]. The advantages of dual grafts in congenital pseudarthrosis and other difficult nonunions are outlined. Fibular grafts are recommended for defects of the humerus.

Fett, Foote, and Stevens,⁵⁸⁵ reporting on delayed union and nonunion in the Navy, state that they use drilling to stimulate union in cases with delayed union. They classify nonunion as (1) pseudarthrosis, (2) fibrous union with osteoporosis and (3) fibrous union with atrophy of tissue. The causation is discussed and the importance of infection and of lack of immobilization is rightfully emphasized. Standard methods of bone grafting are discussed, including thin grafts of cortex and periosteum, especially for the forearm [ED NOTE—The medulla of onlay grafts is cut down with a motor saw, whereas it seems well to leave this on for firm contact with the host]. The use of primary bone grafts is mentioned, and 1 case is reported of its use in a spiral fracture of the tibia [ED NOTE—This fracture does well on primary open reduction and fixation with screws but rarely needs a graft if treated in this manner. Commoner sites such as transverse fracture of the upper ulna, of both forearm bones and of the femur deserve consideration of primary grafting]. [ED NOTE (L. D. B.)—In most cases this fracture does well with a self traction cast, flexed knee and dorsiflexed ankle, plus time, and rarely needs screws or grafts]. They routinely use sulfathiazole locally [ED NOTE—of doubtful value] and penicillin, in both clean and previously infected fractures, postoperatively, and report low incidence of infection but give no statistics. Complications include infection, fracture of graft and fracture of donor site.

584 Boyd, H. B. The Treatment of Ununited Fractures, M. Press 213 116-119 (Feb 21) 1945

585 Fett, H. C., Foote, R. F., and Stevens, M. A. L. The Problem of Delayed Union and Nonunion of Fractures, Am J Surg 69 283-298 (Sept) 1945

[ED NOTE—Reference is made to vitallium screws only, and fractured screws appear in several illustrations. This emphasizes the need for screws of adequate strength and constant physical characteristics.]

Horwitz and Lambert⁵⁸⁶ advocate the use of iliac bone in conjunction with internal fixation in treatment of nonunion, feeling that the osteogenetic quality of iliac bone more than compensates for the lack of rigidity, the latter being furnished by a plate. Furthermore, use of iliac bone avoids the danger of tibial fracture, which is not uncommon when tibial graft is used. They have obtained iliac grafts as large as 25 by 12.5 cm (1 by 5 inches). In compound fractures a period of six months elapsed before use of this method. Their grafts were combined intramedullary, inlay and onlay in most cases. In some of the cases plates which had been inserted earlier were left in place and the grafts were added with fixation by screws. The authors used only suspension and skeletal traction postoperatively, changing to cutaneous traction after ten weeks. Sixteen cases were reported, 10 involving the femur, 4 both bones of the forearm and 2 the tibia. [ED NOTE—This paper confirms the value of iliac bone for grafting and the benefit of firm internal fixation. The details of operative procedure are well presented with illustrations.]

Key⁵⁸⁷ describes the use of dual plates for the fixation of fractures. One plate has threaded holes to receive the distal end of the screws, and a special guide has been designed for accurate insertion of the screws so that they hit the center of the threaded holes. He used this method only in conjunction with bone graft for nonunion. [ED NOTE—This method is well presented as being difficult but of value in selected cases of nonunion. It would seem to have special value in the case of bones which are too soft to afford adequate fixation by standard methods. Where cortical bone is of good quality, a single plate or at the most two standard plates would suffice if the plates and screws are of proper size and design.]

Meekison⁵⁸⁸ reported a series of 30 cases, which were followed for over one year, of massive bone graft fixed with vitallium screws. He stated that he had only 1 known failure in a larger series of 170 cases. He made use of a pneumatic tourniquet. In the case of the femur, it was applied above a Steinmann pin inserted above the greater trochanter.

⁵⁸⁶ Horwitz, T., and Lambert R. G. Treatment of Ununited Fractures of Long Bones. A Method Combining Grafting and Internal Fixation. *J Bone & Joint Surg* 27 637-644 (Oct.) 1945.

⁵⁸⁷ Key, J. A. Dual Plates for Internal Fixation in Nonunion of Fractures of Bone & Joint. *Surg* 27 632-636 (Oct.) 1945.

⁵⁸⁸ Meekison, D. M. The Treatment of Nonunion or Delayed Union of Fractures by Means of Massive Onlay Grafts Fixed with Vitallium Screws. *J Bone & Joint Surg* 27 383-386 (July) 1945.

Tibial graft was used. The method of preparation of the graft and host and the fixation of the graft are described. [ED NOTE—The technic follows well accepted lines. Emphasis is placed on the use of vitallium, but steel products of 18-8 S-Mo are equally inert and effective.]

Mowlem⁵⁸⁹ reports on the use of multiple small chips of cancellous bone in the restoration of defects and loss of contour in 80 cases. This series includes 35 cases of mandibular loss averaging 2 inches (5.08 cm) in length. He states that while the mandible is not weight bearing it must withstand a biting pressure of from 100 to 200 pounds per square inch (7 to 14 Kg per square centimeter). He has used external pins for stability while union was occurring but states that a rigid graft or plate may be desired. He feels that grafts of this type are more resistant to infection than cortical bone. He does not recommend grafting in presence of infection as a method of choice but found it safe and successful in some of his cases, with the benefit of penicillin. Only a small number of these cases involved the long bones.

Hand and Wrist—In treating malunited Colles' fractures Speed and Knight⁵⁹⁰ advise that if malunion is present after two weeks manipulation alone may not suffice to correct it. After a study of 60 malunited fractures they state that the objectives are (1) restoration of anatomy, (2) improved function and (3) improved appearance. The site of the fracture was exposed through a dorsal longitudinal incision of adequate length. The operative procedures were as follows: 1. Simple osteotomy of the distal part of the radius in 23 cases with excision of the prominent portion of the ulnar head in some instances. Twenty per cent had partial recurrence of deformity. 2. The resected portion of the ulnar head was wedged into the site of osteotomy of the radius. This did not always restore the radial length. 3. Intramedullary bone graft was used in the radial osteotomy. This method is best when the distal fragment is osteoporotic. 4. Onlay graft was used in 3 cases, in 1 case a dual graft. 5. Arthrodesis. When the fracture is near the joint with severe comminution or osteoporosis, fusion may be the best procedure, often with resection of the distal part of the ulna. 6. Resection of the distal end of the ulna when disability is due to arthritis at the distal radioulnar joint. In young adults and children especially this should be done extraperiosteally, since the ulna may tend to regenerate after subperiosteal resection. [ED NOTE—This is an excellent article on this subject. The late correction of malunited Colles' fractures is difficult and often disappointing. Special attention must be paid to the soft tissues and maintenance of the function of the hand.]

589 Mowlem R. Cancellous Chip Grafts for Restoration of Bone Defects. *Proc Roy Soc Med* 38 171-174 (Feb) 1945.

590 Speed, J S, and Knight, R A. The Treatment of Malunited Colles's Fractures, *J Bone & Joint Surg* 27 361-367 (July) 1945.

Waugh⁵⁹¹ reviews the anatomy of the carpal scaphoid and the numerous forms of surgical treatment. In complicated cases either arthrodesis of the wrist or excision of fragments is indicated, and the author favors the latter alternative. He reports 3 cases in which the scaphoid was replaced with a vitallium replica, in 2 successfully and in 1 unsuccessfully. The first prosthesis was solid, weighing 29 Gm. Later ones were hollow, weighing from 12 to 17 Gm, compared to 5 Gm for the normal bone. The prosthesis is made in three sizes right and left for proper selection. This method is advised in selected cases including certain fresh fractures. [ED NOTE—This method seems to be promising.]

Callahan⁵⁹² reviews the anatomy of the carpal bones with special reference to the blood supply. A number of cases are presented to illustrate the therapeutic problems involved. He emphasizes the importance of early complete reduction and rigid immobilization until revascularization and union have occurred. Early removal of the ununited proximal fragment of the scaphoid is advised, drilling the bone or grafting of cystic fragments is discouraged.

In the treatment of nonunion of the carpal scaphoid Bentzon and Madsen⁵⁹³ make a preoperative study of the form and position of the fragments by means of stereoscopic roentgenograms. A rather large curved incision is made, with the base of the flap proximal to and just opposite the styloid process of the radius. The joint capsule is then opened to expose the line of fracture. The fracture is cleaned out in such a manner as to leave a noticeable fissure. Then a flap of subcutaneous fat and connective tissue is interposed and precisely fixed between the fragments. For this purpose, a suture is passed through the point of the flap, and both ends of this suture are passed down through the fracture and out on the volar side of the carpus, where the suture is tied over a small gauze tampon. The radial artery lies in the vicinity, but this artery may easily be palpated, since in this operation a tourniquet is not necessary.

The authors claim that the results from the described method of interposition have been encouraging. [ED NOTE—The description of this method does not seem to justify its use in preference to bone grafting. The authors recommend their operation only before arthritic

591 Waugh R L, and Reuling L. Vitallium Replicas as Replacement After Excision in Ununited Fractures of Carpal Scaphoid. Preliminary Report, *Am J Surg* 67 184-200 (Feb) 1945

592 Callahan, J J, Cubbins, W R, Scuderi C S and Hamilton E. Revascularization of the Carpal Bones. *Radiology* 44 171-176 (Feb) 1945

593 Bentzon P G K, and Madsen A R. Surgical Therapy of Pseudarthrosis Following Fractures of Carpal Scaphoid Bone, *Nord med (Hospitals)* 21 524-527 (March 17) 1944

changes occur After these develop fusion of the wrist would seem to be indicated]

Girdwood⁵⁹⁴ makes a strong plea for the prevention of deformities of the hand after fractures, burns and infections The prevention of deformity, atrophy and fixation depends on immobilization of the hand in the position of function with extension of the wrist, flexion of the metacarpophalangeal joints and freedom of motion in the interphalangeal joints

Spine—Rogers⁵⁹⁵ reports 4 cases of paraplegia which developed from a few minutes to forty-eight hours after vertebral injury The patients were all able to walk during the interval and 1 pushed his motorcycle about a mile (1.6 kilometers) before onset of paraplegia Laminectomy was performed in 2 cases after an interval of about six months In these 2, which involved the first lumbar and the eighth dorsal vertebra, recovery was incomplete The other 2 each involved the third and the fourth dorsal vertebrae, paraplegia was incomplete, and they fully recovered within a short period of time The author classifies vertebral injury as (1) vertebral fracture with immediate symptoms referable to the cord, (2) symptomless fracture without injury to the cord, (3) gross injury to the cord even to complete lesion produced by a blow but without demonstrable fracture (1 case cited), and (4) the fracture with delayed symptoms referable to the cord, as in the 4 cases reported The 2 cases in which there was late laminectomy had long compression, this was responsible for the paraplegia, which probably resulted from movement of the fragments The author emphasizes the importance of gentle handling in order to avoid more extensive damage [ED NOTE—The history and observations in the 2 cases in which there was operation would seem to suggest that laminectomy should be done early in this type of case if recovery is not rapid]

Hallock⁵⁹⁶ reports 48 cases of arthrodesis for painful ankle following severe fracture with follow-up after more than one year in 38 cases Pain and limitation of motion were the usual symptoms Anterior incision was used with exposure of all articulating surfaces, and the foot was immobilized in 10 degree equinus position postoperatively In 77 per cent there was solid bony fusion, in 10 per cent there was failure and 13 per cent had doubtful outcome Twenty per cent of the total had residual pain due to failure of fusion, varus deformity, too much equinus or associated arthritis of tarsal joints [ED NOTE—This is an excellent review and should be studied in its entirety]

594 Girdwood, W Immobilization of the Hand and Its Destructive Effects on Hand Function *South African M J* 18 350-352 (Oct 28) 1944

595 Rogers L Delayed Paraplegia Following Fractures of the Vertebrae *Brit J Surg* 32 514-517 (April) 1945

596 Hallock, H Arthrodesis of the Ankle Joint for Old Painful Fractures *J Bone & Joint Surg* 27 49-58 (Jan) 1945

Pseudarthrosis—Lindemann⁵⁹⁷ states that congenital pseudarthrosis is a hypoplastic malformation and is not caused by intrauterine fracture. The signs of hypoplasia are usually first noticeable along the parietal bone, but the structure of the bone in the bent tibia is affected as well. When fracture occurs hypoplasia develops, causing the formation of congenital pseudarthrosis of the leg.

There is no reason to believe that uterine pressure during pregnancy or pathologic modifications of the amnion cause congenital curvatures or fractures of the tibia. Intrauterine tibial fractures frequently occur simultaneously with developmental defects.

In the case of congenital tibial curvatures, fractures may also occur post partum and may lead to pseudarthrosis which is extremely difficult to remedy. On the basis of findings in the literature and of personal cases, the conclusion is reached that the condition is a hereditary hypoplastic malformation in which there is a typical disturbance of tibial structure and growth, with poor formation of callus and bone. [ED. NOTE (L. D. B.)—Moore showed that the so-called congenital pseudarthrosis is another manifestation of neurofibromatosis (von Recklinghausen's Disease) and his belief has been confirmed in many American clinics.] Removal of pseudarthrosis should not be undertaken before the patient reaches the age of 6. The tibia should then be protected by means of bone graft. The hypoplastic fibula of the same side should never be used for bridging. If there is indication of hypoplasia in the other leg the bone graft must be taken from another part of the body.

Malkin⁵⁹⁸ reports 2 cases of congenital pseudarthrosis in which treatment by dual grafts from the opposite tibia was successful. In 1 case fixation was obtained with two screws, and in the other case fixation was obtained proximally by wire, while the grafts were implanted in the lower fragment. He feels that the dual grafts prevent the constricting action of scar tissue which may shut off circulation from a single graft.

Von Rosen⁵⁹⁹ reports 5 cases of pseudarthrosis of the tibia as a result of osteoclasia or congenital curvature. In 3 cases union was successful after several operative procedures. In 1 case nonunion persisted and in 1 case amputation was necessary at the age of 8. [ED. NOTE—This article points out the hazards in attempting to correct this condition.]

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597 Lindemann, K. Pathogenesis of Congenital Pseudoarthrosis. *Z. orthop. Orthop.* **74** 256, 1943.

598 Malkin, S. A. S. Congenital Pseudoarthrosis of Tibia Treated by Tibial Grafts. *Proc. Roy. Soc. Med.* **38** 71-74 (Dec.) 1944.

599 von Rosen, S. Some Cases of Congenital Tibial Pseudoarthrosis. *Acta orthop. Scandinav.* **14** 290-301, 1943.

XVI CONDITIONS INVOLVING THE KNEE JOINT

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Anatomy and Physiology—Haxton⁶⁰⁰ reviews the literature dealing with the function of the patella. Experimental work shows that the patella improves the efficiency of knee extension in the more extended positions by holding the patellar tendon away from the axis and thereby increasing the extending movement of the pull of the quadriceps. Haxton, noting that patellectomy impairs the efficiency of the extensor apparatus, believes that the operation should be avoided if possible but believes it to be indicated in inflammatory and neoplastic diseases of bone and in osteoarthritis when this is confined to the patellofemoral articulation.

Efskind⁶⁰¹ discusses the absorptive function of the synovial membrane. Intra-articular injections of "perabrodil" (iodopyrin injection) were administered in doses of 15 cc, and absorption was controlled roentgenologically. Indigo carmine was administered in doses of 25 cc of 2 per cent solution, and its concentration in the blood and urine was noted. A total of 49 clinical cases with pathologic changes in the knee joint were examined. The following conditions were studied: 1 Hemarthrosis. In cases in which the hemarthrosis was caused by slight injuries to the synovial membrane there was no regular change in absorption for "perabrodil" or for indigo carmine either immediately after injury or later. There was delay when gross injuries had occurred. 2 Hydrops. In these cases no constant change of the absorptive capacity of the joint was observed with either substance. 3 Arthritis deformans. In the initial stages in which changes of cartilage and bone can barely be detected roentgenologically the absorption time was generally prolonged for both substances. In the severe forms of this condition all degrees of functional reduction of the most serious nature were found. The severest affections of the absorptive capacity were often found in cases in which the synovial membrane was very shrunken and the joint cavity thus was much reduced in size. 4 Pyoarthrosis. As is to be expected these cases showed pronounced functional changes.

From the Section on Orthopedic Surgery, Mayo Clinic

600 Haxton, H. The Function of the Patella and the Effects of Its Excision, Surg, Gynec & Obst 80 389-395 (April) 1945

601 Efskind, L. Clinical Studies on the Function of the Synovial Membrane of the Knee Joint. Acta chir Scandinav 88 37-48, 1943

which were roughly parallel to the clinical degree of affection. As the clinical symptoms diminished the absorptive capacity gradually approached normal values.

This study tested the absorptive capacity of the synovial membrane and the subsynovial blood vessels only. Larger particulate material would be necessary for functional tests of the lymph vessels.

Congenital Anomalies of the Knee Joint—Sundt⁶⁰² feels that partition of the patella is caused by the absence of fusion in a normal patella with multiple primary centers of ossification, his histologic examinations support the assumption of the possible presence of aseptic necrosis in cases of patella partita. Analyzing the data on the cases reported in the literature Sundt concludes that it is not justified categorically to deny the presence of an infantile patellar osteopathy in these cases. The anomaly itself does not produce symptoms, and if symptoms do exist he feels that they are due to some coincidental lesion in the knee.

Nickerson⁶⁰³ reviews the development of the knee joint from the embryologic and the phylogenetic aspects. He particularly emphasizes the quadriceps and patellar interrelationship of Carey, who has postulated that formation of joints will occur in those places where centers of growth oppose each other. He presents 2 cases of anomalies of the knee joints with the presence of incomplete vertical septation within the knee. The basic pathologic process has been described as being due to aberrant or pathologic linked genes which possess abnormal mesodermal and ectodermal characteristics, respectively. The primary developmental aberration due to the pathologic gene is manifested by faulty and incomplete differentiation of the premuscular mesenchymal mass which ordinarily is destined to become a portion of the quadriceps extensor apparatus—the vastus internus.

This lack of muscular differentiation has initiated a number of secondary developmental changes in the patella, the quadriceps pouch and the synovial cavity. All these changes have occurred in the medial portion of the knee joint and have exhibited either hypoplastic or aplastic characteristics.

The medial portion of the knee joint possesses older phylogenetic structures than its lateral portion. Anomalies in the medial compartment will present themselves in the form of developmental erasure. Anomalies in the lateral portion will present themselves in the form of accessory growth. It is to be noted that accessory patellar centers are constantly found in the lateral portion.

⁶⁰² Sundt H. On Partition of Sesamoid Bones of Lower Extremities Patella Partita, Especially with Regard to Histological Findings and Relation to Traumatism, Among Others Six Own Cases Examined Histologically, Contribution to Pathology of Patella. *Acta orthop Scandinau* 13 1-152 1942.

⁶⁰³ Nickerson S H. Pathology of the Anomalies Found in Knee Joints. *Am J Roentgenol* 53 213-229 (March) 1945.

Pathologic Conditions of the Knee Joint—Petermann⁶⁰⁴ believes that popliteal cysts arise from the synovial membrane of the knee joint, being primary or secondary to a lesion of the synovial membrane. The most common cyst is that which originates in the bursa of the internal head of the gastrocnemius and the semimembranosus muscle. The cysts of articular origin have the tendency to separate from the joint when they are older, while cysts of tendinous origin have a tendency to open into the joint as they grow older. According to Petermann, only the cysts which communicate with the joint give symptoms of functional impairment. In the first stages they produce only pain radiating from the popliteal space to the calf. In spite of their lateral origin, they appear in the middle of the popliteal space.

[ED NOTE—The idea that only those cases in which the cyst communicates with the joint produce symptoms is not always accepted, and the editors believe that it may be open to question.]

By an ingenious method Hirsch⁶⁰⁵ studied the elasticity of the hyaline cartilage of the patella. The material came from postmortem and operative specimens. It included normal and malacic cartilage. The investigation showed that the healthy articular cartilage had a typical elasticity curve. By staining for chondroitin-sulfuric acid and by chemical analysis it was observed that the content of sulfur bound to esters was lower in malacic than in healthy cartilage. By comparative measurements of elasticity in healthy and malacic cartilage it was shown that whenever the content of chondroitin-sulfuric acid was reduced the cartilage exhibited impaired elasticity, particularly a deterioration in its capacity to withstand loading. The operative specimens showed that malacia with great reduction of the content of chondroitin-sulfuric acid in the cartilage could be present without there being any disintegration of tissue and that when disintegration of tissue did occur it always did so in softened cartilage with a greatly reduced content of chondroitin-sulfuric acid or on the borderline between it and healthy tissue.

Turkell⁶⁰⁶ reports a case diagnosed as mixed rheumatoid and degenerative arthritis in which multiple osteocartilaginous bodies were found embedded in the synovial membranes of both knees to such an extent as to simulate osteochondromatosis.

604 Petermann F E Quistes sinoviales del hueso popliteo, Arch Soc. cirujanos hosp 14 427-429 (June) 1944

605 Hirsch C A Contribution to the Pathogenesis of Chondromalacia of the Patella A Physical Histologic and Chemical Study, Acta chir Scandinav (supp 83) 90 1-106, 1944

606 Turkell, J H Multiple Osteochondral Bodies in Synovial Membrane of Knee Joints in Cases of Mixed Rheumatoid and Degenerative Arthritis J Bone & Joint Surg 27 149-154 (Jan) 1945

Pique and Schajowicz⁶⁰⁷ group under the name "articular lipomatosis" all the diseases, circumscribed or generalized, that originate in the fatty tissues of the synovial membranes with chronic inflammatory and hypertrophic character. They present 3 cases of arborescent lipomatosis, 2 primary and 1 secondary. According to them, the cause in the primary cases was rheumatoid arthritis and in the secondary case was osteoarthritis. The best treatment is synovectomy, sometimes accompanied by patellectomy.

Sjovall⁶⁰⁸ analyzes data obtained from 67 biopsies of synovia of the knee for diagnostic purposes at the Lund Orthopedic Clinic from 1921 to 1938, in order to show the value of this procedure in obscure diseases of the knee joint. In 18 cases (27 per cent), the procedure gave a satisfactory answer to the disease of the involved joint. A clue to the correct diagnosis was provided in 2 more cases on histologic examination. A definite diagnosis of tuberculosis was made by this procedure in 13 of the 18 cases. The suspicion, based on microscopic examination, of tuberculosis in another case could not be verified clinically. Tuberculosis did not develop in any joint shown by biopsy to be free of tuberculosis in a subsequent period of observation of twenty-two to five years as shown by a follow-up study in 89 per cent of the cases.

Wiberg⁶⁰⁹ distinguishes between cases of osteochondritis dissecans in the knees in which the lesion has healed spontaneously, as judged by freedom from symptoms, and cases in which there is roentgenologic evidence of healing. He considers it reasonable to assume that the healing is more complete in those cases in which the bodies of osteochondritis dissecans fuse with the bone so as to leave no trace of the previous process. He reports 5 additional cases in which conservative treatment led to recovery of this kind, in 1 case the lesion was bilateral, so that a total of 6 knees were included. In 3 cases there was a demarcated nucleus, and in 2 cases the process was diffuse. In analyzing these cases Wiberg notes that the patients were less than 16 years of age when the lesion healed, and he concludes that such a process is not likely to heal after the age of 20 years in any case, perhaps not after 16 or 17 years. If in such cases under conservative treatment pieces of cartilage become detached or if there are persistent annoying symptoms he recommends removal by extraction in order to prevent secondary arthritis deformans. He considers the risk with conservative treatment exceedingly slight.

607 Pique, J. A., and Schajowicz, F. Lipomatosis diffusa articular (lipomatosis arborescente), *Bol y trab Soc argent de cirujanos* 5 736-766, 1944, *Rev Asoc med argent* 58 1113-1123 (Dec 15) 1944.

608 Sjovall H. Ueber den Wert der Probeexzision bei schwer zu diagnostizierenden Kniegelenkaffektionen, *Acta chir Scandinav* 89 407-416 1943.

609 Wiberg G. Spontaneous Healing of Osteochondritis Dissecans in the Knee-Joint, *Acta orthop Scandinav* 14 270-277 1943.

[ED NOTE—While there are undoubtedly cases in which osteochondritis dissecans heals spontaneously, it should be emphasized that in such cases the patients must be followed closely, as the damage to the joint may be latent in its clinical manifestations]

Cox⁶¹⁰ discusses the causation and treatment of traumatic osteochondritis of the patella. The following gross pathologic changes were seen: (1) softening, irregularity in contour and formation of fissures in the articular cartilage of the patella, (2) yellowish discoloration of the articular cartilage in the involved regions, (3) similar changes in the articular cartilage of the femoral condyle on its anteromedial aspect, (4) thickening, hyperemia and villous degeneration of the synovium, usually confined to the region of the suprapatellar pouch and the anterior compartment of the knee, (5) increased joint fluid, (6) formation of pannus at the edges of the articular cartilage of the patella and the femoral condyles. In 6 cases the condition was treated by excision of the patella, and the synovium and degenerated femoral cartilage were left undisturbed. Complete recovery with disappearance of the synovitis and effusion was observed in every case.

[ED NOTE—This seems to us an excellent review of this subject, which should be read by every one.]

Wounds and Injuries of the Knee—Burns, Young and Muller⁶¹¹ report the results of treatment in 101 cases of wounds of the knee joint. The treatment routine in forward areas consisted of early excision of the wound in all cases except small puncture wounds, suture of the synovial membrane after excision when possible, packing the wounds lightly with sulfanilamide and petrolatum gauze and the administration of penicillin to most of the patients. On arrival at the Emergency Medical Service Hospital penicillin therapy was instituted in all except 9 cases. Exercises for the quadriceps were begun on admission except in cases in which there were signs of acute inflammation. Of 101 patients, 75 eventually recovered with a normal knee, 15 with a useful knee and 11 with a stiff knee. There were no deaths and no amputations.

The authors credit penicillin with the amazing improvement in results when compared with the results of World War I.

Sjovall⁶¹² records the finding of a ganglion formation in a partially ruptured posterior cruciate ligament in a woman aged 21 years. The trouble in the knee began four years before the operation in relation to some injury of which the nature and force were such as to eliminate the

610 Cox, F. J. Traumatic Osteochondritis of the Patella, *Surgery* 17 93 101 (Jan) 1945

611 Burns, B. H., Young, R. H., and Muller, G. M. Wounds of the Knee-Joint. *Lancet* 1 551-553 (May 5) 1945

612 Sjovall, H. Ein Fall von Ganglion in einem rupturierten Ligamentum cruciatum genus post, *Acta chir. Scandinav.* 87 331-341, 1942

possibility of rupture of a normal posterior cruciate ligament Sjøvall discusses the classification of such processes and the relationship between the clinical history and operative findings The idea that the trauma may have played any pathogenic role is discarded, on the other hand, the possibility of minor traumatic injuries as factors of importance is accepted One must not, however, entirely disregard the possibility of a primary ganglion formation The case illustrates the genesis of ganglion formation Only once earlier has a ganglion with a corresponding localization been described (Coan, 1924)

Internal Derangements of the Knee—West⁶¹³ calls attention to the misuse of the term "internal derangement of the knee" as a diagnosis and notes that the commonest causes for so-called internal derangement of the knee are injuries to the semilunar cartilages and varying degrees of strain or tears of the intrinsic or extrinsic ligaments Under the general heading "internal derangements of the knee" he lists

- 1 Disturbances of the semilunar cartilages
 - a Tears
 - b Cysts
- 2 Disturbances of the collateral and cruciate ligaments
- 3 Disturbances of the articular cartilage
 - a Osteochondritis dissecans
 - b Chondromalacia of the patella
- 4 Dislocations of the patella
- 5 Disturbances of the fat pads
- 6 Other derangements
 - a. Fractures
 - b Osteochondromatosis
 - c Synovitis
 - d Pellegrini-Stieda disease

West points out that accurate diagnosis and immediate institution of proper treatment are necessary to obtain the best results and feels that, especially in cases of ligamentous injury, proper early treatment, either surgical or conservative, will usually give good results, while late attempts to repair ligamentous injury are discouraging, if not hopeless

The anatomy of the knee is discussed, and it is pointed out that "the first maxim in the treatment of knee conditions is to strengthen the quadriceps—for without adequate quadriceps power a normal knee will not be obtained"

One hundred consecutive cases of derangement of the knee joint admitted to West's service in an army general hospital are tabulated according to diagnosis, and there are excellent brief discussions of the diagnosis and treatment of the various types of internal derangement

⁶¹³ West, F E Diagnosis and Treatment of Internal Derangements of the Knee S Clin North America 25 111-135 (Feb) 1945

Severin⁶¹⁴ describes a peculiar free body originating in a knee joint. This body, which clinically was observed freely movable in the joint for six or seven weeks, consisted of a blood clot partly surrounded by coarsely trabecular, collagenous connective tissue, poor in cells. The presence of capillary vessels in this "capsule" indicates that the clot was formed subsynovially and later became detached. Since the connective tissue had not become necrotic, it must have been nourished by the synovia.

Jaekle⁶¹⁵ reports his results in 155 cases of torn semilunar cartilages. Operation was not advised or done if it appeared that the patient had not the will to get well. In all cases the patient was taught exercises for the quadriceps before operation. In the repair of bucket handle tears only the torn portion was removed and the border of the remaining portion was cleanly excised. For other types of tear most of the meniscus was removed but a small rim was left. Surgical intervention was advised within a short time after injury, particularly in bucket handle cartilages not reduced by manipulation. One hundred and thirty-two patients, 85 per cent, were returned to regular duty on an average of twenty-five days after operation for injuries incurred from a few days to eleven years before.

Sjövall⁶¹⁶ reports a clinical analysis of data on 144 cases of total meniscal extirpation performed in the orthopedic clinic at Lund, Sweden, in the period of 1929 to 1938. When the patients were followed up by questionnaires, it was found that 2 patients had died. In all but 1 case a reply was made to the questionnaires. Out of 120 men and 23 women with 116 medial and 33 lateral menisci removed, 60 per cent were manual laborers. Thirty-three per cent of primary lesions were due to athletic injuries. Coincidental pathologic changes were injuries to cruciate ligaments (in 11 per cent of the patients), osteochondritis dissecans (in 6 per cent), chondromalacia of the patella (in 27 per cent), and arthritis deformans (in 10 per cent). The average period of hospitalization was one month. The average stay at home was one month. Manual laborers resumed work on the average later than nonmanual workers and insured persons resumed work later than uninsured persons.

The function of the knee was estimated with a view to the appearance of the knee, its mobility and gross strength, and the presence of

614 Severin, E. Eigentümlicher freier Körper im Kniegelenk. *Acta chir Scandinav* 88 33-36, 1943.

615 Jaekle, R. F. Internal Derangements of the Knee Joint. *Arch Surg* 50 271-276 (May) 1945.

616 Sjövall, H. Die Spätergebnisse nach totaler Menisceuxstirpation, klinische Analyse und Nachuntersuchung von 144 in den Jahren 1929-1938 an der Lunder Orthopädischen Klinik operierten Fällen. *Acta orthop Scandinav* 13 153-217, 1942.

crepitation and pain. Also considered was the influence of the length of the period of observation, duration of illness and age of patients at time of injury, operation and reexamination.

Group	Results	Cases	Percentage of Group
I	Perfectly free from all inconvenience	28	20
II	Good results practically free from inconvenience with merely an insignificant subjective complaint	72	52
III	Fair results more pronounced inconvenience slight functional disturbances	57	26
IV	Poor results and marked in part disabling trouble in none of these 3 cases are results due to meniscectomy as such	3	2

These results do not support warnings of several clinicians against operative treatment of meniscal lesions. Sjoval indicates that subjective symptoms in these cases do not show a more frequent tendency to arthritis deformans than in other series and goes against the assumption that surgical treatment enhances the risk of early postoperative arthritis deformans. He discusses indications for surgical treatment and advises immediate operation when there is recent unquestionable meniscal injury or lesion. In obscure cases he advises conservative treatment, the first sign of a relapse will then constitute an absolute indication for arthrotomy.

Stanek⁶¹⁷ reports the results of 150 consecutive arthrotomies of the knee done in military service. No infection was noted in the entire series. Operations were done with the patient under spinal anesthesia. A narrow Esmarch tourniquet was used. In 2 cases transient paralysis was noted. In simple cases of meniscal injuries, following excision and closure, sheet wadding and muslin dressings were applied. Exercises for the quadriceps were initiated on the first postoperative day. The patient was allowed up and about without crutches, often on the second or third postoperative day, as soon as he could raise the leg from the bed unassisted.

In 105 cases there was injury only to the menisci, ligaments or fat pads. Eighty-six medial and 15 lateral torn menisci were removed. In 2 cases only was there injury to both menisci of the same knee. Fifty-four bucket handle, 20 anterior, 10 posterior and 3 minimal tears (loose anterior attachments) were noted. Ninety-seven of the 105 patients who had such injuries returned to some type of duty. In 24 cases there were disorders of bone or articular cartilage including 9 cases of osteochondritis dissecans and 11 cases of chondromalacia of the patella. In 5 cases there was severe arthritis. In 9 cases there were old or recent fractures of the patella, tibial spine or tibial plateau. In 4 cases purely exploratory arthrotomy was done with uniformly poor results. Three unusual conditions involving the knee were noted and described in detail, including a hemangioma of the fat pad with invasion

617 Stanek, W. F. Internal Derangements and Fractures Involving Knee. Results of One Hundred and Fifty Consecutive Arthrotomies Performed at St. On Hospital, J. Bone & Joint Surg. 27 96-94 (Jan) 1945.

of the patellar ligament Stanek is of the opinion that simple cases of meniscal injuries show a high percentage of excellent operative results which are not affected to any extent by injuries of the cruciate ligaments. Concomitant injuries of collateral ligaments or chondromalacia of the patella gives a poor prognosis. Loose bodies with old osteochondritis dissecans have a good prognosis following surgical treatment. The prognosis as to return to military duty following operation is poor in cases showing arthritis or fractures of the tibial plateau.

Bingham and McDonald⁶¹⁸ report a case in which a young soldier serving in India presented the typical history and physical findings of a cyst of the external semilunar cartilage of the knee, but at operation the lesion was found to be a cyst lying between the capsule and the synovial membrane, which on microscopic examination proved to be a filarial nodule. Attention is called to the fact that the statements made by other authors that a cartilage cyst is the only tense swelling which is located exactly in the middle of the lateral surface of the knee at the level of the joint line or that cartilage cysts are the only form of cyst occurring on the lateral joint line are not quite true.

Dislocations of the Knee—Lasher⁶¹⁹ notes that complete dislocations of the knee unaccompanied by fractures are sufficiently rare to deserve reporting. The marked lateral angulation and rotation accompanying such dislocations are frequently accompanied by circulatory changes, emphasizing the urgent necessity of the earliest possible reduction. A cadet, aged 23 years, dislocated his left knee while playing football. The exact mechanism of the injury was not determined. When the patient arrived at the hospital fifteen minutes after the injury the entire leg and foot were completely blanched. An immediate reduction, with the patient under general anesthesia, was made on the x-ray table. Firm traction was exerted on the leg while at the same time the patella was forced upward and direct pressure was made to overcome the lateral displacement. The reduction was accompanied by a local thud, and almost immediately the circulation in the toes returned to normal. A circular cast was applied with the joint in extension. The cast was cut throughout its entire length and the following day there was considerable swelling. The joint was acutely painful for seven days. On the fourteenth day the foot was partially freed from the plaster and the patient was permitted to use crutches. On the twenty-fifth day the cast was removed and a walking caliper was applied, which he continued to wear for two months after the injury. Physical therapy and exercises were begun on the twenty-seventh day and continued for three months from the date of

618 Bingham, J. A. W. and McDonald S. A Filarial Nodule Simulating a Cyst of the External Semilunar Cartilage. *Brit. J. Surg.* 32: 326-327 (Oct.) 1944.

619 Lasher, W. W. Complete Dislocation of the Knee Unaccompanied by Fracture, *Indust. Med.* 14: 188-189 (March) 1945.

injury When the caliper was removed an elastic bandage was used for a month Carefully supervised exercises developed the thigh to its original size Several months after the injury there was no evidence of the original injury, and the patient was carrying out his duties as an aviation officer

Roentgenologic Examination—Andersen,⁶²⁰ after pointing out that the methods for arthrography of the knee hitherto employed have not given fully satisfactory results, especially as regards the visualization of the semilunar cartilages, proceeds to give a description of a method first advanced by Mohemann and Madleuer in 1942 Briefly, the method consists of injection of a gaseous mixture, such as nitrous oxide, which Andersen used, into the knee joint and then roentgenoscopic and roentgenographic examination of the knee while traction with adduction or abduction is applied to the leg to allow diffusion of the gas completely around the semilunar cartilages About 60 to 100 cc of the gas is injected under sterile precautions, the patient is placed in a prone position on the table, and the thigh is immobilized with a strap Roentgenoscopic examination of the knee is then performed with an assistant to move the leg as the observer directs The semilunar cartilages are said to be visualized clearly and, with proper adjustment of the projection, roentgenograms are taken of the knee in straight and posteroanterior views, with slight inward rotation, maximal internal rotation and slight and maximal lateral rotation, in orienting front and side pictures and, lastly, in Frik's projection

Grossman and Minor⁶²¹ found that by combining the injection of a small amount of air with forced abduction and adduction of the knee during roentgenography they were able to visualize both semilunar cartilages satisfactorily The site chosen for the injection is just lateral to the patellar ligament at the knee joint through the ligamentum mucosum A 20 gage needle with a 30 cc syringe is used After the fluid has been aspirated, 10 to 20 cc of atmospheric air filtered through several thicknesses of gauze is slowly injected into the joint After the air has been injected the needle is withdrawn and the puncture wound is sealed with collodion A device for immobilizing the knee and one for applying the lateral traction on the thigh are desirable Anteroposterior roentgenograms are made in abduction to visualize the medial semilunar cartilage and in adduction to visualize the lateral one Roentgenograms are made in the prone and supine positions in order to visualize the posterior and anterior horns The Trendelenburg position is used to keep any fluid remaining in the joint in the anterior suprapatellar

⁶²⁰ Andersen K. Some Experiences with a New Method for Arthrography, *Acta radiol* 25 33-39 1944

⁶²¹ Grossman, J W, and Minor, H H Roentgen Demonstration of the Semilunar Cartilages of the Knee, *Am J Roentgenol* 53 454-465 (May) 1945

extension of the articular cavity. The thigh is elevated to prevent contact of the patella with the table so that true positioning may be obtained.

Because each case varies, there are no constant pathologic pictures with the exception of bucket handle tears with dislocation. The pathologic changes seen may be gross or minimal and consist of fractures or tears with or without degenerative changes (thinning and fraying). The cruciate ligaments are often visualized. In several cases effects of the articular cartilage have been noted. It is well to do pneumographic studies on several normal knees to become acquainted with the normal appearances. It is claimed that the use of small amounts of air precludes the possibility of air embolism. The authors have found that the lateral meniscus is fractured more often than is believed, and in many cases both cartilages have been shown to be pathologic.

Surgical Procedure—Abbott and Carpenter⁶²² present a discussion of the anatomic details of surgical approaches to the knee joint based on their clinical experience and that of their colleagues, on a comprehensive review of the available literature on the subject and on a survey of a number of dissections performed on cadavers and freshly amputated specimens. Surgical approaches are planned either to avoid the exposure of vital structures or to expose them deliberately. The first method may be used if adequate exposure of the lesion or lesions can be secured and if there is only a remote possibility of injury to vital structures. The writers, however, stress the use of the second method in all instances in which the incision is planned to give the most direct access to the lesion, regardless of the proximity of vital structures. In order to expose vital structures in the path of the dissection or in its immediate vicinity an exact knowledge of the anatomic relations involved is paramount, and on this premise the authors proceed to develop their discussion. General anatomic considerations of the knee are given first with a description of the capsule, the synovia, the bursas, the blood supply and the cutaneous nerves surrounding the joint.

The various approaches to the knee joint are then considered with a concise but complete description of the surgical anatomy on the anterior, medial, posterior and lateral aspects of the knee joint, the indications for the various approaches as each is described, the position of the patient in each, the anatomic landmarks for each incision and a detailed anatomic description of each approach.

Approaches to the anterior aspect of the knee joint are described under the following headings: the parapatellar incisions, including the median parapatellar incision (von Langenbeck), the S-shaped parapatellar incision (Payr), the oblique parapatellar incision (Erkes) and

⁶²² Abbott, L. C., and Carpenter, W. F. *Surgical Approaches to Knee Joint*, J. Bone & Joint Surg. 27: 277-310 (April) 1945.

the lateral parapatellar incision (Kocher), incisions which divide the patella, including the vertical division of the patella (Brackett and Hall, Jones), the transverse division of the patella (von Volkmann), sagittal division of the patella (Devine) and the oblique division of the patella (Bougout and De La Rue), incisions which divide the tendon of the quadriceps muscle, with resumes of the method of plastic division of the quadriceps tendon as described by Putti and by Campbell and plastic division of the quadriceps tendon as described by Coonse and Adams, the incisions which divide the patella transversely including the U-shaped incision (Textor) and the H-shaped incision (Ollier)

An S-shaped incision to the medial aspect of the joint which extends from 2 inches (5 cm) above the adductor tubercle to the joint level, then forward to the anterior border or the upper end of the tibia and then downward to end just below the tibial tubercle is described minutely. In cases in which a more limited exposure is sufficient a straight or simple curved incision extending downward from the adductor tubercle is mentioned

As was done in respect to the approaches from the medial aspect an S-shaped incision for approaching the lateral aspect of the knee joint is given with indications for the approach, position of the patient, anatomic landmarks and surgical anatomy and with a complete anatomic description of the incision. As in the case of the medial aspect of the knee, a straight or curved incision is mentioned for use in cases in which only limited exposure is needed

The following approaches are described for the removal of the semilunar cartilages: approach for partial removal of the internal semilunar cartilage, approach for complete removal of the internal semilunar cartilage, approach for partial removal of the lateral semilunar cartilage and approach for complete removal of the external semilunar cartilage. In regard to approaches for removal of the internal semilunar cartilage the Cave, Bosworth and Fisher incisions are described

The following bilateral incisions are described: incisions for exposure of the popliteal face of the femur (Henry), approaches for epiphyseodesis (Abbott and Gill), incisions for removal of loose bodies from the posterior compartment of the knee (Henderson) and approaches for posterior capsulotomy in flexion contractures of the knee (Wilson). A midline approach to the posterior aspect of the knee joint through the popliteal space is detailed. The last section is a discussion of the various approaches for drainage of sepsis of the knee joint

Burge⁶²³ describes the removal of the medial semilunar cartilage of the knee through a single anterior capsular incision facilitated by the use of a "broad sharp dissector" and a "narrow dissector". These

⁶²³ Burge, R. E. A Sharp Dissector for Meniscectomy. *Surgey* 16 956-958 (Dec) 1944

instruments are used to cut the cartilage free from its capsular and fibrous attachments after the capsule has been incised. The instruments are constructed from sharp periosteal elevators in such a way as to be safe for their intended purpose and should be of value to the orthopedic surgeon.

Labry⁶²⁴ discusses treatment of recent hemarthrosis. In such cases he uses aspiration with immobilization for ten days. In case of ligamentous tear a procaine hydrochloride block is carried out. The same procedure is carried out in cases in which the patient is seen one month or less after injury, while in cases in which the patient is seen several months after injury Labry advises long immobilization, frequent infiltration, lumbar infiltration, perifemoral sympathectomy and physical therapy.

Morrison⁶²⁵ describes an eyelet knife designed and fashioned from a hacksaw blade. With this knife, blind dissection of the posterior part of the cartilage became the easiest part of the operation. The anterior and medial aspects of the cartilage were detached under direct vision in the usual manner. The cartilage was passed through the eyelet of the knife and while tension was kept on the cartilage, the posterior part was easily removed.

Only structures within the eyelet can be cut as the knife automatically retracts other structures and blind dissection is not hazardous.

Haggart and Thomas⁶²⁶ record experience with arthrodesis of the knee joint in 3 cases, using the Stader splint. The diagnoses were tuberculosis, completely unstable knee and destructive arthritis, respectively. They prefer the curved type of resection of the femur and tibia, with removal of a minimal amount of bone, thus preserving the maximal leg length. The operative technique is a modification of the original Hibbs operation, and comprises minimal bone resection of the condylar surfaces, followed by countersinking the patella in the femur and tibia as a bridging bone graft. Ten days later, with the patient under intravenous pentothal sodium anesthesia, the sutures are removed from the operative incision and the Stader splint then is applied, the proximal pins in the femur, the distal pins in the tibia. The unit is then "taken up" so that by roentgenologic examination adequate contact of the raw bone surfaces is evident. A roentgenogram of this position is again secured in two or three weeks, when the unit is further tightened so that firm impaction is maintained.

624 Labry R. A propos du traitement difficile des hydrohemarthroses traumatiques du genou. *Lyon chir* 37 73-78 1941-1942.

625 Morrison, G M. A New Knee-Cartilage Knife. *U S Nav M Bull* 44 404-405 (Feb) 1945.

626 Haggart G E, and Thomas, G L. Use of the Stader Splint in Arthrodesis of the Knee Joint (Preliminary Report), *Lahey Clin Bull* 4 85 89 (Jan) 1945.

The Stader splint is removed in six to eight weeks and a snug-fitting, long leg plaster cast is applied, adjusted for weight bearing. The patient thereupon becomes ambulatory with crutches and progressively bears weight on the extremity. The patient is kept in bed during the time the pins are in place in order to minimize the chance of infection of the pin tract. None of the patients so treated has exhibited pin seepage.

In the 3 cases described, firm bone ankylosis of the knee joint was demonstrated both clinically and roentgenologically in twenty weeks, twelve weeks and twelve weeks, respectively.

Thompson⁶²⁷ points out that residual disability following severe injury to an extremity is just as often due to loss of function of the soft parts as to malunion, nonunion or infection of the bones. The latter conditions can be prevented or corrected, but with injuries of the soft parts complete restoration of normal function is rarely attained, since when tissues with very specialized functions are replaced or surrounded by scar tissue considerable loss of function is inevitable. Excision and isolation of scar tissue in the extensor mechanism of the thigh is described as an operative procedure to increase motion in the knee, particularly flexion, following injuries to the thigh. Nineteen cases are reported, in all of which satisfactory results were obtained as far as increase of flexion is concerned. Thompson's method involves excision of the scarred vastus intermedius, the knee is flexed to 90 degrees or beyond, without lengthening the rectus femoris muscle, by making a new intermuscular septum of soft tissues. The intact rectus femoris permits early active motion, and this factor is the reason why most of these patients have regained full active extension.

[ED NOTE—Thompson's operation is an advance in the treatment of postfracture fixation of the knee. In our experience the adhesion of the capsule of the knee joint to the margins of the joint has been a prominent finding in these cases and flexion cannot be obtained until the adhesion is freed.]

Guildal⁶²⁸ reports 4 cases of complete or almost complete ankylosis of the knee at an angle between 120 and 80 degrees. The cause of the ankylosis was an inflammatory process in the knee. The knee was straightened out by osteotomy, wedge-formed in 2 cases, arcuate in 2 followed by wire traction (through the tuberosity of the tibia or the calcaneum). The results were practically complete straightening of the angle and firm osseous ankylosis. Two cases were complicated, one by exacerbation of the earlier osteomyelitic process, the other by the fact that the traction wire cut through the bone and gave rise to osteitis.

⁶²⁷ Thompson, T. C. Quadricepsplasty, *Ann Surg* **121** 751-754 (May) 1945.

⁶²⁸ Guildal, P. Ankylosis of the Knee with Marked Angulation. Straightening by Osteotomy and Wire-Traction, *Acta chir Scandinav* **87** 138-144 1942.

In all cases a reduction was obtained in the practical shortening and the patients were able to get along with a heightened boot

Recurrent Dislocation of Patella—Sjovall⁶²⁹ reports on 27 patients (30 knees) on whom operation was performed for recurrent dislocation of the patella, 2 patients (3 knees) for habitual dislocation, and 4 patients (5 knees) for persistent dislocation (Blumensaat classification). Cases were analyzed from pathologic, etiologic and clinical points of view. He describes surgical technic and observations on reexamination. The Krogius operation was suitable as basal procedure, only in a few cases was it supplemented. There was a relapse in 3 (12 per cent) of the cases of recurrent dislocation, and this was due to intense strain or forceful injury. No relapse was noted in cases of habitual dislocation. In 1 case of persistent dislocation a relapse occurred, recurrent dislocation developed in one knee, but the other knee had excellent function. There were excellent results in 97 per cent with the Krogius procedure and less satisfactory results in 3 per cent of the cases. The results were attributed to consistency of treatment, low average age of patient and the selection of cases. Early operative treatment is emphasized.

XVII CONDITIONS INVOLVING THE KNEE JOINT

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Roentgen Diagnosis—Gershon-Cohen⁶³⁰ describes roentgenographic technic for observation of the soft tissue of the knee. Anteroposterior, lateral, oblique, longitudinal and intercondylar roentgenographic views of both knees should be made routinely. By strong traction, abduction or adduction of the leg, a transient vacuum can be created in the articular space and the outline of the menisci will be revealed in the roentgenogram. More than 8 to 10 cc of synovial fluid, however, interferes with such a vacuum and prevents visualization of the menisci. The

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629 Sjovall H. Zur Frage der rezidivierenden und permanenten Knieverrenkungen unter besonderer Berücksichtigung der Behandlung und Behandlungserfolge, *Acta orthop. Scandinav.* 14:185-218 (1943)

630 Gershon-Cohen, J. Internal Derangements of the Knee Joint. The X-Ray Diagnosis, *Rhode Island M. J.* 28:570 (Aug.) 1945, Internal Derangements of the Knee Joint. The Diagnostic Scope of Soft Tissue Roentgen Examinations and Vacuum Technic Demonstration of Menisci, *Am. J. Roentgenol.* 54:338-347 (Oct.) 1945, Derangements of the Knee Joint. Diagnostic Aid Obtained by the Roentgenologic Examination of the Soft Structures and of the Menisci Without Injection of Contrast Media, *U. S. Nav. M. Bull.* 45:488-499 (Sept.) 1945

author feels that loose bodies, sprain of the tibial collateral ligaments, periarticular bursitis, cysts of the menisci, neoplasms and miscellaneous lesions of soft tissue can be diagnosed if this technic is used

McGaw and Weckesser⁶³¹ discuss the use of pneumarthrography in 508 examinations of the knee among army personnel. They describe the technic when oxygen is used and outline a method of interpreting the findings. Of interest are the popliteal bursas which were found to communicate with posterior pouches in 14.4 per cent of the 508 knees examined in this way.

Herzog⁶³² states that the main indication for pneumarthrography is in distinguishing simple traumatic synovitis which calls for conservative management from torn menisci which need operative management.

Wounds of the Knee—Newman⁶³³ discusses the early treatment of wounds of the knee. He divides the wounds into three groups, "slight," "moderate" and "severe." He presents data on 10 slight wounds, 39 moderate wounds and 8 severe wounds in a total of 57 cases. For the group of slight wounds treatment consisted of aspiration, intra-articular administration of penicillin and immobilization of the extremity in a cast. For the group of moderate wounds treatment consisted of careful excision, primary suture, intra-articular and parenteral administration of penicillin and immobilization of the joint in extension with a Thomas splint. The group of severe wounds presented a more difficult problem. Five wounds were left open. The author stresses the need of roentgenographic examination as an aid to diagnosis, and the early removal of foreign bodies.

Mitchell⁶³⁴ analyzes 800 consecutive cases of injury of the knee among army personnel. He found that 13.5 per cent of the 800 patients had penetrating wounds of the knee, four fifths of which were war wounds. Thirty per cent had a lesion of the meniscus, 25 per cent synovitis of various types, 7 per cent a ligamentous injury and 6 per cent osteoarthritis.

Internal Derangement of the Knee—[ED. NOTE—Many articles continue to be written on the management of internal derangements of the knee, especially tears of the menisci among military personnel. Most of them seem to be in agreement as to selection of cases and operative results in general.] Willien⁶³⁵ presents the results of a two year

631 McGaw, W. T., and Weckesser, E. C. Pneumarthrograms of Knee. Diagnostic Aid in Internal Derangements. *J. Bone & Joint Surg.* **27**: 432-445 (July) 1945.

632 Herzog, E. G. Air Arthrography in Diagnosis of Torn Semilunar Cartilage. *Lancet* **2**: 5-6 (July 7) 1945.

633 Newman, P. H. Early Treatment of Wounds of Knee Joint. *Lancet* **2**: 632-633 (Nov. 17) 1945.

634 Mitchell, G. A. G. Analysis of Eight Hundred Consecutive Knee Cases. *Rev. Army M. Corps* **83**: 271-273 (Dec.) 1944.

635 Willien, L. J. Second-Year End Results of Arthroplasties of Knee. *Bull. U. S. Army M. Dept.* **4**: 452-456 (Oct.) 1945.

follow-up in 75 cases in which arthrotomy of the knee was performed in an army hospital within the continental limits of the United States. In the majority of the cases a torn meniscus or osteochondritis dissecans was present. Sixty-two and six-tenths per cent of the men were retained in the army, 38.6 per cent on full duty and 24 per cent on limited service. Willen concludes that if derangement of the knee antedates enlistment, the patient should be reclassified or discharged. If it is connected with service, he should be operated on if this is the treatment indicated, after careful evaluation of his emotional status.

Dwyer and Taylor⁶³⁶ report a case of discoid internal meniscus of the knee. They assume that this is the only case of internal discoid meniscus reported in the literature. The patient was a soldier, 29 years old, who had signs and symptoms compatible with a bucket handle tear. At operation a complete fibrocartilaginous "dish" was found with a longitudinal tear.

Mitchell⁶³⁷ studied 241 cases in which lesions of the menisci were present. The cases were obtained from 800 cases in which consecutive operations were performed on the knee. In 73 per cent the internal cartilage was torn and in 17 per cent the external. In 9 per cent a cystic cartilage was found, and in 1 per cent a discoid cartilage. Pathologic studies revealed degenerative changes in the cartilage and synovial membrane in cases in which the injury had occurred sometime previously and relatively little change in cases in which it was recent. The cystic cartilages were polycystic.

Another statistical study of army personnel was done by Garden,⁶³⁸ who studied 628 cases of internal derangement. In 325 of these a diagnosis of torn semilunar cartilage was made, and in 206 operation was performed. An anterior incision was used. If the anterior half of the cartilage remained attached to the posterior half, no posterior incision was used. If the anterior half had separated from the posterior half, a posterior incision was made in addition. All the cystic cartilages were removed to prevent recurrences.

Mintz⁶³⁹ studied more than 100 injuries to the knees treated conservatively and 64 treated surgically. In 62 of these injured menisci were present and in 2, cysts. Mintz warns against operating on military patients who have osteoarthritic changes, but advocates this procedure in civil practice when indicated. [ED NOTE—This is the

636 Dwyer, F. D., and Taylor, C. Congenital Discoid Internal Cartilage. *Brit. M. J.* 2: 287 (Sept. 1) 1945.

637 Mitchell, G. A. G. Lesions of Fibrocartilages. Study of Types, Positions and Pathological Changes, *J. Roy. Army M. Corps* 83: 198-200 (Oct.) 1944.

638 Garden, R. S. Meniscectomy in Soldier, *J. Roy. Army M. Corps* 84: 119-124 (March) 1945.

639 Mintz, B. J. Internal Derangements. Diagnosis and Treatment. *Am. J. Surg.* 70: 189-196 (Nov.) 1945.

consensus of those experienced in military surgery] He also advocates complete excision of the cartilage through two incisions

Studies on civilians have also been made Du Toit and Enslin⁶⁴⁰ analyzed 100 cases in which arthrotomy was performed for injured meniscuses They carefully evaluated all preoperative signs and symptoms They found at operation tears of the medial cartilages in 82 cases, of the lateral cartilages in 9, no tear in 4, bilateral tears in 3 and a discoid meniscus in 2 In correlating their observations with the physical signs they found that (1) pain in the anteromedial line of the joint is of diagnostic importance, (2) absence of this pain contraindicates arthrotomy, (3) locking frequently but not always occurs, (4) damage to a meniscus may exist in the absence of wasting, (5) osteochondritis dissecans and traumatic lesions of the cartilage of the medial patellar facet (Fouche's hot spot) may cloud the diagnostic picture and (6) most of these findings favor early and total meniscectomy

Cave, Rowe, and Yee⁶⁴¹ report the results of a two year follow-up in 121 cases in which arthrotomy was carried out in an overseas army hospital Of the patients admitted to the hospital with complaints referable to the knee, 29 per cent required operation The significant observations were as follows 1 Of those who demonstrated a torn meniscus at operation, 98 per cent gave a history of a twist injury of the knee, 70 per cent of locking, 95 per cent of swelling of the joint and 97 per cent of pain or injury 2 Physical observations of importance consisted of (a) atrophy of the quadriceps muscle in 68 per cent of the cases of torn meniscuses, (b) tenderness in the line of the joint and prominence of the meniscus in 88 per cent, (c) excess articular fluid in 50 per cent and (d) limitation of motion, especially extension, in 63 per cent 3 Operative findings in the 88 cases of torn meniscuses were tears in the medial cartilage in 87 per cent and in the lateral cartilage in 12 per cent Osteochondritis dissecans was found in 15 of the 121 cases Patellar chondromalacia was found in 11 cases 4 Postoperative complications consisted of sepsis in 1 case, thrombophlebitis in 1 and temporary sciatic nerve palsy in 4 cases

Schwartz⁶⁴² in another study made in an overseas hospital found that of 110 patients admitted in fifteen months, 16 per cent were admitted for injuries to the knee Of this 16 per cent, 31 per cent were operated on

640 du Toit, G T and Enslin, T B Analysis of One Hundred Consecutive Arthrotomies for Traumatic Internal Derangement of Knee Joint, *J Bone & Joint Surg* 27 412-425 (July) 1945

641 Cave, E F, Rowe, C R, and Yee, L B K Selection of Cases for Arthrotomy of Knee in Overseas General Hospital Two Year Follow-Up Study *J Bone & Joint Surg* 27 603-607 (Oct) 1945

642 Schwartz M Injured Knee, *Bull Ho p Joint Dis* 5 55-59 (Oct) 1944

An analysis of the surgical cases is presented. The author is an advocate of the 5 inch (12.7 cm) parapatellar incision in all cases.

Harmon⁶⁴³ reports 2 interesting cases of osteochondral fractures in adolescents, and he is of the opinion that the condition should be better known. In one case the lateral femoral condyle was involved, in the other the patella, after dislocation. Because of the amount of cartilage present in adolescents, roentgenologic visualization of osteochondral fractures is difficult. Treatment is early arthrotomy and excision of the loose fragment.

Wilkinson and Burt⁶⁴⁴ blame the poor results in arthrotomy on (1) unnecessarily long periods in the hospital and (2) delay in treating the complications. They mention localized periarthritic tenderness, synovial effusion, instability of the joint and inability to "brace back" the knee.

Heebner⁶⁴⁵ discusses the "first aid" treatment of sprains of the knee and tears of cartilage. He emphasizes the application of cold instead of heat to the knee for the first two or three weeks.

Pellegrini-Stieda Disease—Allen⁶⁴⁶ based his study on 1,564 cases in which roentgenologic examination of the knees was made at a large station hospital. In 28 cases Pellegrini-Stieda disease (calcification of the medial collateral ligament of the knee due to trauma) was found. The lesion was bilateral in 7 cases. Twenty-six patients had pain, limited motion, swelling after use or localized tenderness. There was a history of trauma in 21 cases. Allen considers trauma the inciting cause of hemorrhage around the medial epicondyle into the attachments of the tibial collateral ligament, vastus medialis or adductor magnus. Organization of this hemorrhage results in deposition of calcium at this site.

Nachlas and Olpp,⁶⁴⁷ on the other hand, stated that the disease is due not to a fragment of bone from the femur, a tear of the periosteum, or a calcified bursa but to a process of attrition on the inner aspect of the sliding membrane over the adductor tubercle. This attrition is speeded by the tissue swelling of polyarthritic or traumatic arthritis. They also stress the coexistence of chronic arthritis of the knee. They emphasize that Pellegrini-Stieda disease is not a disease complex.

643 Harmon, P. H. Intra-Articular Osteochondral Fractures as Cause for Internal Derangement of Knee in Adolescents. *J. Bone & Joint Surg.* 27:703-705 (Oct.) 1945.

644 Wilkinson, L. H., and Burt, H. A. Knee Injuries in Soldiers. *Lancet* 1:684-686 (June 2) 1945.

645 Heebner, R. A. Sprains in Knee Joint Injuries, *Hosp. Corps Quart.* 18:40 (Nov.) 1945.

646 Allen, W. E., Jr. Post-Traumatic Para-Articular Calcification of Knee Joint, *J. Nat. M. A.* 37:164-167 (Sept.) 1945.

647 Nachlas, I. W., and Olpp, J. L. Para-Articular Calcification (Pellegrini-Stieda) in Affections of Knee, *Surg., Gynec. & Obst.* 81:206-212 (Aug.) 1945.

[ED NOTE—This is certainly true. A new name, based on a description of this condition, is needed, how about "paracondylar calcification of the femur?"]

Patellar Chondromalacia—Cave, Rowe, and Yee⁶⁴⁸ consider that chondromalacia of the patella is a definite pathologic entity. They state that the progress of this condition is as follows: first phase, patellar contusion, second phase, chondromalacia, and third phase, degenerative chondral changes and synovitis.

In 9 (7 per cent) of 124 consecutive cases in which arthrotomy was performed for internal derangement of the knee chondromalacia of the patella was found. The gross and microscopic pathologic changes then are discussed. It is emphasized that the roentgenograms did not reveal abnormalities. Treatment is surgical and is of three types, depending on the severity of the disease: (1) removal of the involved tissues, (2) patelloplasty, with horizontal resection of two thirds of the patella and interposition of the fat pad between the remainder of the patella and the condyles and (3) patellectomy.

Soto-Hall⁶⁴⁹ found chondromalacia of the patella in 12 (18.5 per cent) of 65 consecutive cases in which arthrotomy was performed. In 6 of these 12 total patellectomy was done. Soto-Hall classifies surgical procedure into the same three types that Cave, Rowe, and Yee did.

Traumatic Degeneration of the Head of the Gastrocnemius Muscle—Cohen⁶⁵⁰ presents a case of traumatic degeneration of the medial head of the gastrocnemius muscle simulating a semimembranous bursa. A man 39 years old fell and struck the popliteal region. When he was examined three weeks later, a globular cystic swelling was present posteriorly in the popliteal space. A diagnosis of semimembranous bursa was made. At operation a swelling composed of fibrofatty material involving the medial head of the gastrocnemius muscle was found. On microscopic examination striated muscle which had undergone degeneration, atrophy and replacement with fat was noted. Cohen postulates that trauma caused deep rupture of the medial head of the gastrocnemius with secondary degeneration and fatty replacement, or that it produced infarction and secondary degenerative changes.

Physical Medicine—Wilson⁶⁵¹ reports on what he calls "an active assistive exerciser" to help correct extension contractures of the knee.

648 Cave, E. F., Rowe, C. R. and Yee, L. B. K. Chondromalacia of the Patella, Surg., Gynec. & Obst. **81** 446-450 (Oct.) 1945

649 Soto-Hall, R. Traumatic Degeneration of Articular Cartilage of Patella. I Bone & Joint Surg. **27** 426-431 (July) 1945

650 Cohen, H. H. Traumatic Degeneration of Medial Head of Gastrocnemius Simulating Semimembranous Bursa. Case Report, I Bone & Joint Surg. **27** 720-722 (Oct.) 1945

651 Wilson, G. D. Active Assistive Knee Exerciser, Mil. Surgeon **97** 156 (Aug.) 1945

It uses only passive motion which is induced by means of pulleys and force

DeLorme⁶⁵² in a somewhat new concept of exercises for the knees presents a system of exercises to increase muscular power and endurance. He concludes that low repetition, high resistance exercises produce power and that high repetition, low resistance exercises produce endurance. The indications for each type of exercise vary. He considers that this system of exercises should always precede weight bearing and that it is contraindicated in chondromalacia when open operation has not been performed.

Weakened atrophic muscles should be given power-building exercises first, that is, low repetition, high resistance exercises. When power has been restored, the patient should start on endurance exercises, that is, high repetition, low resistance exercises. Use of both of these forms of exercise should be increased gradually.

Surgical Technic and Results—Because of a relatively high percentage of recurrence when the standard technics for treatment of recurrent dislocation of the patella were employed, McCarroll and Schwartzmann⁶⁵³ have abandoned them, namely, (1) transplantation of the lateral half of patellar tendon into the inner surface of the tibia, (2) transplantation of the semitendinosus tendon to the patella and (3) transplantation of the tibial tubercle medially and distally in the shaft of the tibia.

In the place of these procedures they substituted a combined operation in 23 cases with completely satisfactory results and no recurrences to date. The operation consists of transplanting the tibial tubercle and placing the semitendinosus tendon into the patella at the same time. A detailed description of the operative technic is given.

Lapidus⁶⁵⁴ reports a successful fusion of a Charcot knee (neurogenic arthropathy of the knee). After removal of synovium and other diseased tissue the ends of the bone were approximated and fused with a vitallium plate, plus two crossed vitallium screws of the wood type. The patient was in a plaster cast for four months postoperatively, and after this a long brace was used on the leg.

Young and Regan⁶⁵⁵ review the literature on total patellar excision for arthritis and then present 21 cases in which excision of the patella

652 DeLorme, T. L. Restoration of Muscle Power by Heavy-Resistance Exercises, *J. Bone & Joint Surg.* 27: 645-667 (Oct.) 1945.

653 McCarroll, H. R., and Schwartzmann, J. R. Lateral Dislocation of Patella. Correction by a Simultaneous Transplantation of Tibial Tubercle and Semitendinosus Tendon. *J. Bone & Joint Surg.* 27: 446-452 (July) 1945.

654 Lapidus, P. W. A Few Facts Concerning Operative Fusion of Charcot Knee. Report of Case, *Bull. Hosp. Joint Dis.* 6: 33-40 (April) 1945.

655 Young, H. H., and Regan, J. M. Total Excision of the Patella for Arthritis of the Knee, *Minnesota Med.* 28: 909-914 (Nov.) 1945.

was performed for arthritis at the Mayo Clinic. Bilateral excision was performed in 5 cases. The follow-up period after operation was one to four years. Osteoarthritis was present in 14 cases, rheumatoid arthritis in 6 cases and traumatic arthritis from recurrent dislocation of the patella in 1 case.

In 7 of the cases of osteoarthritis excellent results consisting of freedom from pain and a range of motion from at least 90 to 170 degrees occurred. In 4 of the 6 cases of the rheumatoid arthritis, improvement occurred. In 1 case of traumatic arthritis the results were good. Of the 21 patients, 9 said they had no pain after operation, 11 had less pain and 1 was not improved.

Tavernier⁶⁵⁶ discusses the stiffness in the knee resulting from traction with Kirschner wire through the femoral condyles. He states that this extension contracture is due to "adhesions below and along the patellar border, anchoring the patella to the femur." He utilizes a midline incision, frees the rectus muscle, separates the patella laterally from the vastus muscles and leaves the patellar tendon intact. The knee is then flexed to a right angle to break the remaining adhesions, and mobilization is started on the fourth or fifth day.

A follow-up study in 19 cases of relaxation of the knee joint has been made by Palmer⁶⁵⁷. In 12 cases operation was carried out for relaxation of the anterior cruciate ligament and medial collateral ligament, in 4 cases for relaxation of the posterior cruciate ligament, and in 3 for relaxation of the collateral ligaments alone. Reinforcement of the ligaments was done with a flap from the iliotibial ligament. In 2 cases histologic studies revealed that the reconstructed ligaments had survived and grown in place. The operative technic is described.

XVIII CONDITIONS INVOLVING SHOULDER, NECK AND JAW

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In 1945 there were a number of papers dealing with conditions involving shoulder, neck and jaw.

Conditions of the Shoulder—Dislocations. Pettersson⁶⁵⁸ discusses the pathology of the dislocated shoulder. He reviews the anatomy of the shoulder joint with special emphasis on the tendon aponeurosis.

656 Tavernier, L. Technique de la cure opératoire des raideurs incoercibles du genou après les fractures du fémur traitées par traction sur broche de Kirschner, *Ly. chir.* 40 9-14 (Jan-Feb.) 1945.

657 Palmer, I. Plastic Surgery of the Ligaments of the Knee, *Acta chir Scandinav.* 91 37-48, 1944.

658 Pettersson G. Rupture of Tendon Aponeurosis of Shoulder Joint in Antero-Inferior Dislocation. Study on Origin and Occurrence of Rupture. *Acta chir Scandinav.* (supp 77) 87 1-187, 1942.

The physiologic movements of the shoulder joint are described, especially the synchronous movement of "scapulohumeral rhythm." The aid of roentgen rays in diagnosis of rupture of the tendon aponeurosis is illustrated. This is done by the method of Lindbloom (1939) with the use of "perabrodil" (iodopyrin injection). Tears and rents in tendinous cuff have been shown to occur at as early an age as 30 and have been found to increase with age. Some claim that rupture results from trauma, others as a result of progressive degenerative processes.

The after-care of dislocations following reduction is emphasized by Tavernier⁶⁵⁹. Two cases are reported in which a Poulliquen apparatus was used with the arm in 75 degree abduction and in incomplete external rotation.

Magnuson⁶⁶⁰ has introduced another operation for recurrent dislocation of the shoulder. He feels that the main cause of recurrent dislocation of the head of the humerus is due to muscular imbalance and not a tear of the capsule, tearing of the anterior lip of the glenoid or even lack of support by the muscles.

He therefore transplants the tendinous attachment of the subscapularis muscle with a wedge-shaped piece of bone from the lesser tuberosity to the greater tuberosity. When the new location for the attachment of the subscapularis muscle is determined, a sharp, thin-bladed chisel is driven into the greater tuberosity, with the edge of the blade held parallel to the long axis of the bone. The chisel is moved back and forth laterally to spread the cancellous bone and leave a wedge-shaped gutter, into which is forced the wedge-shaped piece of bone attached to the subscapularis tendon. The tendon is sutured to the capsule with no 00 chromic catgut suture, and sutures are repeated on both sides of the wedge so that the sides of the gutter are firmly in contact with the inserted bone. The lower border of the muscle and tendon are then tacked down with interrupted sutures far enough under the head of the humerus so that the muscle and capsular tendon have a firm grip around the head, with no tendency to slip up toward the coracoid process and the glenoid when the arm is brought into abduction and external rotation.

[ED NOTE—The author shows no proof for the statement that recurrent dislocations are due to muscular imbalance and not to a tear of the capsule from the anterior lip of the glenoid.]

Kunz⁶⁶¹ reviewed the technic of the Nicola operation with a modification employed by Nicola. Emphasis is placed on the proper place

659 Tavernier. After-Care of Luxations Following Reduction. *Lyon chir* 37 345-348, 1941-1942.

660 Magnuson P. B. Treatment of Recurrent Dislocation of Shoulder, *S Clin North America* 25 14-20 (Feb) 1945.

661 Kunz H. G. Nicola Operation. *Mil Surgeon* 96 429-432 (May) 1945.

ment of the tunnel through the head of the humerus, reenforcement of the long head of the biceps with a strip of the coracohumeral ligament and securing the tendon in the tunnel

Bush⁶⁶² describes a modification of the Nicola operation for recurrent dislocation of the shoulder. The biceps tendon and bicipital groove are exposed through the usual incision and the tendon retracted without dividing it. The bicipital groove is then deepened with a gouge or osteotome to form a channel $\frac{1}{2}$ inch (1.27 cm) deep extending $\frac{1}{2}$ inch above the anatomic neck to the point of exit of the bicipital tendon from its sheath. The tendon is replaced and a tension suture is placed through the tendon and the fascia and its distal exit from the channel. The tendon sheath is closed over the tendon. Further stability is obtained by plicating the anterior capsule. The arm is immobilized for three weeks, at which time graduated exercises are begun, reaching full use in eight weeks. The technic has been used on 20 patients, with no recurrences at the end of several weeks. Only 2 patients have been followed for over one year, with no recurrences.

Asplund⁶⁶³ reports a case of bilateral voluntary posterior dislocation of the shoulder in a youth, aged 18, who showed tendency to luxations in some other joints. One of the shoulders has been surgically treated with a good result by bone grafting.

Orell and Petren⁶⁶⁴ present a treatment for recurrent dislocations by bone grafting. Their method consists of inserting os purum peg into a slot made on the neck of the scapula just medial to the rim of the glenoid cavity just below the middle of the rim of the glenoid. Special instruments to create the slot and insert the lamella are used. Anatomic observations are described showing methods of surgical approach to the neck of the scapula. Avoidance of injury to muscles, tendons, vessels and nerves is demonstrated. The operation is all extra-articular.

Ricard, Clavel and Francillon⁶⁶⁵ report a case of recurrent dislocation of the shoulder treated by the Oudard operation followed by a fracture of the coracoid process at the end of three years. This case was then successfully treated by a Hibbinette type of operation in which a bone graft is inserted just medial to the anterior lip of the glenoid on the neck of the scapula.

⁶⁶² Bush, L. F. Dislocations of Shoulder. *Am J Surg* 67:520-523 (March) 1945.

⁶⁶³ Asplund, G. Habitual-Voluntary Posterior Luxation. Case with Recovery Following Bone Graft. *Acta chir Scandinav* 87:103-112 1942.

⁶⁶⁴ Orell, S., and Petren, T. Anatomic Observations in Treatment of Recurrent Dislocation of Shoulder Joint by Bone Grafting. *Acta chir Scandinav* 87:285-297, 1942.

⁶⁶⁵ Ricard, Clavel, and Francillon. Recurrent Luxation. Oudard Operation Followed by Fracture of Coracoid Process at End of Three Years. Preserved Bone Graft. *Ann chir* 37:331-335 1941-1942.

Bicipital Tendovaginitis Bicipital tendovaginitis is relatively common in young males engaged in strenuous activities⁶⁶⁶ This may be due to the constant movement and overuse of the tendon as it arches over the head of the humerus The authors feel that because of this the tendon falls prey to infection They found that the right shoulder is more commonly affected in right-handed persons The condition responds to infiltration—first with 10 cc of 1 per cent procaine hydrochloride in and about the tendon and tendon sheath and then with 15 cc of isotonic solution of sodium chloride injected in the same areas After the immediate relief there is an increase of symptoms for the first twenty-four to forty-eight hours

Tendogenetic disease, according to Borak,⁶⁶⁷ may be treated successfully with roentgen rays Healing wounds under the influence of roentgen rays show that the amount of fibrin between the edges of the wound is much less in the irradiated wound The roentgen rays do not dissolve the fibrin but dilate the capillaries and increase their permeability Roentgen rays in small doses may cause the disappearance of calcified deposits in cases of acute disease, while large doses are required in cases of chronic disease The roentgen rays have a direct action not on the calcium deposits but on the underlying inflammatory process It is the postradiation edema carrying phagocytic cells which causes the dissolution of the calcium deposits

The author places his cases in three groups Group 1 is marked by complete, or nearly complete, immobilization of the affected part The pain sets in suddenly and is intense, producing a strong spasm, so that the arm is adducted to the body This group is treated with 100 r, given on two or three successive days to prolong the duration of the postradiation edema and thus increase the cells functioning as phagocytes Group 2 is marked by restriction of the mobility of the affected arm The arm is not fixed, as in the first group, but can be abducted 40 to 60 degrees This group is treated with 200 r given six to eight times at intervals increasing from two to four days The portals of entrance, one anterior and one posterior, are required in these cases After a month a new series of treatment is added, if necessary, until the deposit is reduced in size and density and the pain on moving the arm has subsided Group 3 is marked by lack of any restriction when the shoulder is moved actively, but pain is experienced at the extremes of the range of motion when the arm is raised over 80 degrees The muscles are not spastic but may become atrophic This group is treated by doses of 250 r given eight times at intervals of two days

⁶⁶⁶ Kaplan, I W, and Hawkins, B L. Bicipital Tendovaginitis *Am J Surg* 70 383-385 (Dec.) 1945

⁶⁶⁷ Borak, J. Tendogenetic Disease and Its Treatment with X-Rays *New York State J Med* 45 725-729 (April 1) 1945

Kabat⁶⁶⁸ claims relief of pain in subacromial bursitis by subcutaneous injections once or twice daily of 2 cc of neostigmine methylsulfate in a $\frac{1}{2000}$ solution (1 mg) plus $\frac{1}{100}$ grain (0.65 mg) or $\frac{1}{150}$ grain (0.43 mg) of atropine sulfate. The atropine is used to eliminate the unpleasant parasympathetic side effects of the neostigmine.

Howorth⁶⁶⁹ exposed the bursas and calcareous deposits in 23 shoulders. The calcareous deposit in all the cases was in the tendinous cuff and had ruptured into the bursa in only 1 case. The character of the deposit varies from a milklike fluid to a dry granular material. The tendon adjoining the deposits was degenerated and often infiltrated with small masses of calcareous material.

The cause of the condition is obscure, but the author considers that the pressure of the supraspinatus tendon against the head of the humerus with the arm at the side, plus sudden, resisted movements, creates sufficient pressure against the tendon to produce degeneration and eventual calcification.

Results of the operative evacuation were uniformly good in early cases with liquid deposit, only fair in chronic cases. In all cases in which manipulation was attempted preoperatively, the condition became worse.

Operative removal is the preferred treatment in cases of chronic disease, and, while uniformly successful as in cases of acute disease, it offers greater relief than physical therapy, roentgen rays or injection.

In cases of acute disease, relief may be obtained by rest, heat, diathermy, cold, ethyl chloride spray or roentgen therapy. However, operative removal gives the most prompt relief and assures permanent healing of the lesion.

Neviaser⁶⁷⁰ studied the pathologic changes in periarthritides of the shoulder through the surgical exploration of the shoulder joint in 10 cases and through dissection of 63 shoulders in the autopsy room.

None of the 10 cases showed pathologic changes in the subacromial bursa on gross examination, but varying degrees of inflammatory change were found microscopically in 7 cases.

The capsule in 9 cases was contracted and closely adherent to the humeral head at its anterior, inferior portion. There were also adhesions in the reflected fold distal to the anatomic head.

All adhesions were freed and normal motion was restored by manipulation. These observations were confirmed on autopsy specimens.

668 Kabat H. Neostigmine Therapy of Sub-Acromial Bursitis, *Pub Health Rep* 59 1635-1650 (Dec. 22) 1944.

669 Howorth, M. B. Calcification of Tendon Cuff of Shoulder, *Surg, Gynec. & Obst.* 80 337-345 (April) 1945.

670 Neviaser, I. S. Adhesive Capsulitis of Shoulder. Study of Pathologic Findings in Periarthritis of Shoulder, *J Bone & Joint Surg* 27 211-222 (April) 1945.

The author concludes that the essential pathologic change is an "adhesive capsulitis," that full motion may be restored by manipulation with the patient under anesthesia and that the term "periarthrits" should be abandoned.

A new traction device for the treatment of the so-called frozen shoulder is presented by Stein⁶⁷¹. It consists of an inverted Blake board suspended from a Balkan frame. A system of pulleys is used whereby the patient can do his own manipulation by pulling or sliding the ropes in the system. The range of motion of the shoulder can be made complete from adduction to abduction.

The patient is placed on two mattresses and the pillow for his head is placed at the foot of the bed to allow for complete abduction of the shoulder.

Shoulder Girdle—Bloom⁶⁷² emphasizes the reason for failure of operative procedures in the acromioclavicular separation which attempt to produce a fixed union at the joint. Loss of ability of the clavicle to rotate interferes with abduction. For this reason, rigid fixation material should be used only with the knowledge that it must be removed after healing has occurred.

The author describes a method of maintaining reduction of the joint by means of a towel clamp inserted in drill holes placed in the outer end of the clavicle and the acromium. The author uses the Murray closed method of insertion of wires across the joint. Twelve cases are reported with good results following routine removal of the fixation wires sixty days after insertion.

Dorling⁶⁷³ reports 2 cases of dropped shoulder and winged scapula. In 1927 Professor Arnold K. Henry described an operation for slinging a dropped shoulder. The condition followed division of the spinal accessory nerve during an operation for tuberculous glands of the neck eighteen months before. It was successfully treated by slinging the scapula to the spines of the sixth cervical and third dorsal vertebrae by means of fascial strips from the thigh.

The author modified Henry's original method by turning up a single flap instead of making four separate incisions, and in the case of the dropped shoulder by slinging up the outer border of the clavicle as well as the scapula. The after-treatment was also simplified.

The technic of the operation consisted of passing strips of fascia lata through two drill holes in the vertebral border of the scapula, passing

671 Stein, R. O. Shoulder-Ankylosis-Swinging Traction Suspension Apparatus. New Shoulder Mobile Traction. *Bull. Hosp. Joint Dis.* 6: 26-28 (April) 1945.

672 Bloom, F. A. Wire Fixation in Acromioclavicular Dislocation. *J. Bone & Joint Surg.* 27: 273-276 (April) 1945.

673 Dorling, G. C. Fascial Slinging of Scapula and Clavicle for Dropped Shoulder and Winged Scapula. *Brit. J. Surg.* 32: 311-315 (Oct.) 1944.

around the spinous processes of the sixth cervical and third thoracic spinous processes. A skeletal abduction plaster was applied including a pelvic band and a plaster armcuff connected by two plaster struts anteriorly and posteriorly.

Kuhns⁶⁷⁴ reports on the variations in the vertebral border of the scapula. He states that there are three types of vertebral borders of the scapulas: concave, straight and convex. Thus the results of muscular action on the scapula, as a continued strong pull upward and outward, can produce a convex vertebral border. Powerful action of the serratus anterior, the pectoralis major and the latissimus dorsi may bring this about. The change from a concave to a straight vertebral border was frequently observed in growing children. No important clinical significance is attached to these scapular variations.

Other Conditions of the Shoulder. Behrens⁶⁷⁵ enumerates the readily recognized causes of pain in the upper extremity, disability and abnormal sensation, including contusions, sprains, fractures, dislocations, acute infections, rheumatic fever and calcium deposits in the shoulder cuff.

In the more obscure cases, the author advises roentgen studies of the cervical spine and the upper thorax. Occasionally, such unusual conditions as vertebral or cord tumors, infectious processes, extensive synostoses or cervical ribs will be found. More often, arthritic changes in the cervical vertebrae and thinning of the intervertebral disks will be found. The importance of both hypertrophic changes and thinning of the disks in producing pain in an upper extremity is emphasized, although the degree is not always directly proportional to the severity of symptoms.

These cases do not respond to the usual methods of medical treatment or diathermy. Manipulation, traction and massage are helpful but roentgen therapy is most effective.

The mode of action of roentgen therapy is one of substitution of active circulation for passive congestion associated with low grade inflammatory conditions.

In cases of cervical arthritis and thinned disks the influence of roentgen rays is on the irritated and congested soft tissues of the affected segments. Reduction of swelling and improvement of the circulation reduce pressure on nerve roots with resultant improvement in symptoms. In cervical arthritis, the improvement is slow as compared with calcific lesions of the shoulder cuff. Pressure symptoms due to arthritic spurs will not improve.

⁶⁷⁴ Kuhns, J. G. Variations in Vertebral Border of Scapula. Relation to Muscular Function. *Physiotherapy Rev.* 25: 207-210 (Sept.-Oct.) 1945.

⁶⁷⁵ Behrens, C. F. Roentgenologic Considerations Pertaining to Upper Extremity Pain. *J. A. M. A.* 127: 888-890 (April 7) 1945.

Slobe⁶⁷⁶ discusses the reflex pain in the arm secondary to fibromyositis of the shoulder girdle and back. The mechanism of the referred pain is apparently due to local areas of induration and infiltration constituting "trigger zones" acting as foci of irritation as a result of which pain is referred reflexly to distant parts. They are treated by the injection of 10 cc of 1 per cent procaine hydrochloride without epinephrine into the local tender area. Repeated injections are given at intervals of from one to four days.

Evans and Krah1⁶⁷⁷ have made a phylogenetic survey of the humerus from fish to man. Anatomists have been cognizant of the twisted appearance of the humerus since the middle of the nineteenth century. There is a difference between torsion of the humerus and rotation of the humerus. Rotation is turning the humerus about its long axis, a motion which does not change the relationship of the opposite ends of the bone to each other. An instrument, torsionmeter, was used. Humeral torsion, which first appears in labyrinthodonts and is retained by all later terrestrial tetrapods with forelegs, is the result of an evolutionary or hereditary (primary) torsion on which is superimposed an ontogenetic (secondary) torsion produced by muscular forces. Torsion of the humerus has occurred in a medial direction.

Osteochondritis dissecans of the supratrochlear septum of the humerus is discussed by Crysler and Morton⁶⁷⁸. They describe it as a localized lesion of the intra-articular portion of the supratrochlear septum of the humerus. It was previously confused with sesamum cubiti.

There may be a supratrochlear foramen or thin septum in the opposite humerus. Local impingement of the coronoid or the olecranon process may be a contributory primary agent. The condition may be due to a vascular abnormality during growth.

Symptoms may exist or remain subclinical for a considerable time. The minimal traumas associated with the onset of clinically noticeable symptoms cannot be considered the major causative agent. The nucleus may be extended as a loose body into the elbow joint. Surgical removal is the treatment.

The Neck—Davis⁶⁷⁹ reviews the functional anatomy of the cervical part of the spine, emphasizing the importance of straightness of the cervical part when there is no obvious fracture or dislocation.

676 Slobe, F. W. Reflex Phenomena in Arm Secondary to Fibromyositis of Shoulder Girdle and Back, *Proc Interst Postgrad M A North America* (1944), 1945, pp 236-239.

677 Evans, F. G., and Krah1, V. E. Torsion of Humerus. Phylogenetic Survey from Fish to Man, *Am J Anat.* 76 303-337 (May) 1945.

678 Crysler, W. E. and Morton, H. S. Osteochondritis Dissecans of Supratrochlear Septum of Humerus, *Am J Roentgenol* 54 41-46 (July) 1945.

679 Davis, A. G. Injuries of Cervical Spine. *J A M A* 127 149-155 (Jan 20) 1945.

Spasm of the cervical musculature holds the spine in the staightened position to avoid painful contact with injured facets or the capsule of facets. Subsequent roentgenograms with the cervical part of the spine in extreme flexion will seem to localize the lesion by demonstrating forward luxation permitted by rupture of the articular capsule and the posterior common ligament. Further localization is shown by root distribution of pain and muscular spasm.

These patients should be treated with a hyperextension collar for a minimum of three weeks to allow repair of fibrous tissue and prevent chronic disability.

The management of obvious lesions, fracture or dislocation, is reviewed with emphasis on immediate traction and early laminectomy when subarachnoid block is demonstrated.

Lyon⁶⁸⁰ reviews 40 cases showing localized hypertrophic lesions peculiar to the cervical part of the spine and the body of the first thoracic vertebra which he terms "uncovertebral osteophytes" and to which he attributes neuralgic symptoms referred to the arms, the neck and the back of the head.

The lesions are described as hypertrophic spondylitis (marginal bony proliferations) due to degenerative changes of the annulus fibrosus and arthrosis deformans of the posterior articulations with osteophytes protruding into the intervertebral foramina, producing pressure symptoms. A further cause of marginal proliferations is osteochondrosis of the cervical part of the spine with degenerative changes of the disk and body and secondary osteophytes.

Clinically, patients complained of boring brachial pain, radiating to arms, pain in the back of the neck and the head, and occasionally dizziness, tinnitus, ear ache, dysphonia and transitory swelling of the arm. Muscular strength was impaired, but sensory disturbances were rare. Treatment is palliative.

Browder and Watson⁶⁸¹ review 22 cases with compression of the cervical part of the cord and spinal root caused by herniation or protrusion of a part of an intervertebral disk.

Three different types of pathologic processes were encountered (1) discrete, oval or rounded nodules projecting into the ventral vertebral canal, (2) true dorsal herniations of the nucleus pulposus, and (3) ridges of the annulus fibrosus surrounding hypertrophic bone at the margins of the adjacent vertebra.

A negative reaction to the Queckenstedt test does not rule out the presence of such a lesion.

⁶⁸⁰ Lyon, E. Uncovertebral Osteophytes and Osteochondrosis of Cervical Spine. *J Bone & Joint Surg.* 27:248-253 (April) 1945.

⁶⁸¹ Browder, J., and Watson, R. Lesions of Cervical Intervertebral Disc. *Clinicopathologic Study of Twenty-Two Cases.* *New York State J. Med.* 45:70-737 (April 1) 1945.

Davies⁶⁸² states that the pantopaque visualization by the Spurling-Scoville method of the canal of the cervical part of the spine revealed lateral herniation of the nucleus pulposus in 4 cases. Symptoms of pressure on the cervical nerve roots were present in these 4 cases. The articular space was diminished at the site involved.

Elliott and Kremer⁶⁸³ reported on 8 cases of brachial pain from herniation of the cervical intervertebral disk. They showed uniform distribution of pain in the back of the shoulder, down the back of the arm and the radial border of the forearm, and sometimes in the upper pectoral region. There were areas of paresthesia in the thumb, the index and the middle finger. In some cases there was a history of acute stiff neck.

The signs included limitation of movement of the neck, pain produced in the arm by movements of the neck and by downward pressure on the head and tenderness, weakness and wasting of the upper fibers of the pectoralis major, the triceps and the extensors of wrist and fingers. The triceps jerk was reduced or absent, and there was usually hypoaesthesia on the thumb and the index finger.

The clinical picture was that of a lesion of the seventh cervical root by herniation of the sixth cervical intervertebral disk.

Love⁶⁸⁴ discusses the scalenus anticus syndrome with and without a cervical rib.

The diagnosis is made on (1) a history of pain, atrophy, circulatory abnormalities, disturbance of sensation and paresthesia in the upper extremity, (2) reduction or obliteration of the radial pulse when scalenus muscle is put on tension, as in extending the neck with the head turned to the affected side when taking a deep breath (Adson maneuver), and (3) the fact that pain is usually felt along the inner side of the arm in the course of the internal cutaneous, the ulnar and the median nerves.

The author states that not all patients with the cervical ribs require treatment. In the conservative treatment the load on the shoulder girdle is lessened, there is application of heat locally, the patient is instructed to sleep with the hands over the head or prone with the arms over the sides of a narrow bed, and acetylsalicylic acid is used. The radical treatment consists of division of the scalenus anticus muscle with or without the removal of the cervical rib.

682 Davies H. Lateral Prolapse of Cervical Intervertebral Disk. *Brit J Radiol* 18 1-4 (Jan) 1945.

683 Elliott, F A, and Kremer, M. Brachial Pain from Herniation of Cervical Intervertebral Disk. *Lancet* 1 4-8 (Jan 6) 1945.

684 Love, J G. Scalenus Anticus Syndrome with and without Cervical Rib, *Proc. Staff Meet. Mayo Clin* 20 65-70 (March 7) 1945.

Cervical ribs⁶⁸⁵ occur in 1 per cent of all persons but give symptoms only in 5 to 10 per cent of the cases. The symptoms are due to compression of the brachial plexus and sometimes of the subclavian artery too between the cervical rib or its fibrous continuation and the scalenus anticus. Of 12 patients, 10 were women.

Symptoms of pain, lessened power, impaired sensation, paresthesia and sometimes a sensation of chilliness are present.

Scalenotomy, division of ligament, resection or partial removal of the cervical rib were types of operative procedures used.

Walshe, Jackson and Wyburn-Mason⁶⁸⁶ also discuss the anatomic pathologic and physiologic changes in cervical rib abnormalities. They stress the damage to the subclavian artery which may lead to its aneurysmal dilatation with or without formation of a clot within it. Thrombosis may occur leading to ischemia and gangrene of the fingers.

The Jaw—Converse⁶⁸⁷ shows a modification of the previous Converse-Waknitz external fixation apparatus for fractures of the mandible. It is smaller and lighter. It has a jackscrew which permits variations of distance between twin pin units.

Lateral variations of each pin unit are also possible as in the angular appliance. The small universal joints are modifications, of a smaller size, of the joints utilized by Clouston-Walker.

Rushton and Walker⁶⁸⁸ describe the uses of the Clouston-Walker screw pin in cases of (1) mandibular fractures without loss of bone for the fixation of fragments which have few or no teeth and which are or may become displaced, (2) as a fixation of bone grating the mandible, where it is especially valuable in maintaining a displaced ascending ramus in its corrected position, and (3) as a fixation for the malar bone when owing to delay in correction it has become fixed in a bad position.

Other uses illustrated are to prevent deviation of the remains of a mandible and indirectly to support a loose maxilla.

Elvidge and Baxter⁶⁸⁹ discuss the treatment of multiple fractures of the facial bones with an external pin fixation splint which is a modification of the Roger Anderson splint. It can be used in cases

685 Privtz, D. Cervical Rib, *Acta psychiat et neurol* **19** 301-319, 1944

686 Walshe, F. M. R., Jackson, H., and Wyburn-Mason, R. Pressure Effects Associated with Cervical and Rudimentary and "Normal" First Ribs and Factors Entering into Their Causation, *Brain* **67** 141-177 (Sept.) 1944

687 Converse, J. M. Appliances for External Fixation of Mandible and Cranial Fixation of Maxilla, *Am J Orthodontics (Oral Surg Sect)* **31** 111-112 (Feb.) 1945

688 Rushton, M. A., and Walker, F. A. Uses of Screw-Pin in Maxillofacial Cases. *Brit Dent J* **78** 289-292 (May 18) 1945

689 Elvidge, A., and Baxter, H. Treatment of Multiple Fractures of Facial Bones with External Pin Fixation Splint, *McGill M J* **13** 469-475 (Dec.) 1944

in which there is associated fracture of the cranium or severe injury to the brain in which a craniotomy may be necessary. The splint may be applied to the cranium at a distance from the cranial fracture so that extensive lacerations or severe hematomas can be attended to without disturbing the fixation of the facial fractures.

No plaster of paris caps are used as they are clumsy, nonrigid and uncomfortable and may cause pressure sores.

The operation may be carried out early and splints are applied with the patient under local anesthesia. Associated fractures of the zygomatic nasal and mandibular bones may be reduced and retained in position by extension bars from the main splint which supports the maxilla.

Thoma⁶⁹⁰ reviews the history of the treatment of the mandibular condyle from the time of Desault. A classification of the types of fractures of this bone is presented. He reports 32 cases of such fractures, 5 were bilateral and 22 were unilateral. In 16 cases other mandibular fractures were present.

Conservative treatment is inadequate as a result of ensuing pain, limited motion and malocclusion.

In children due to epiphyseal growth, better results followed conservative treatment, but in adults operative procedures were found necessary for satisfactory end results.

Open operative wiring of fragments was advocated in cases of wide separation or marked overriding and displacement of the condyle.

Walker⁶⁹¹ presents a screw pin for use in connection with mandibular fractures and grafts. A thicker and more rigid pin is used in contrast to the thinner pins previously used in the Clouston-Walker apparatus for fractures of the mandible.

690 Thoma, K. H. Fractures and Fracture Dislocations of Mandibular Condyle. Method for Open Reduction and Internal Wiring and One for Skeletal Fixation with Report of Thirty-Two Cases, *J Oral Surg* 3 3-59 (Jan) 1945.

691 Walker, F. A. Screw-Pin for Use in Connection with Mandibular Fractures and Grafts, *Brit Dent J* 78 266-267 (May 4) 1945.

REVIEW OF UROLOGIC SURGERY

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Hydronephrosis—Hinman¹ discusses the various problems and types of surgical treatment in hydronephrosis. He states that the only cure is removal of the obstruction causing the condition and that, therefore, the first step in treatment is to determine the cause, degree, complexity and site of the obstruction. The condition of the renal parenchyma must be determined as, in addition to hydronephrotic atrophy, acute, chronic or atrophic pyelonephritis may be present which would cause progressive loss of renal function even after removal of the obstruction. The aim in treatment is preservation of renal tissue with the least risk.

In ureteropelvic obstruction, if an uninfected hydronephrotic kidney is capable of performing a fifth to a fourth of total function and reserve potentialities exist there is good reason to attempt plastic repair, otherwise, nephrectomy is indicated. If hydronephrosis is bilateral nephrectomy should be performed only when a kidney is functionless. If repair is indicated it is best to repair the poorer side first because (1) post-operative renal insufficiency and the danger of anuria will be less and (2) optimal repair of both kidneys will be secured. The repaired poorer

¹ Hinman F. Hydronephrosis. IV. The Surgical Treatment. *Surgery* 20: 337-350 (Sept) 1946.

kidney is stimulated to build up its reserve during the period of lessened function following repair of the better kidney. The second operation should not be delayed too long, as delay alters the potentialities for increasing the function of each kidney. Plastic repair in hydronephrosis may consist of (1) pelvioureterolysis, (2) incision and closure of the stenosed portion with or without plication or partial pelvectomy, (3) reimplantation of the ureter into the pelvis, often with plication or partial pelvectomy or (4) one or more of these methods combined with use of a ureteral splint, nephrostomy or pyelostomy, nephropexy or denervation of the renal pedicle. An excellent group of drawings demonstrating these procedures is presented. The method to be used can be decided on satisfactorily only after the kidney and ureter have been well exposed and the situation carefully studied. In exposing the kidney it is important that the line of cleavage be back of the retrorenal fat leaving the quadratus lumborum and the psoas muscles cleanly uncovered. The posterior surface of the kidney cleaned down to its capsule adheres firmly to these muscles later. In pelvioureterolysis the surgeon must decide whether or not to preserve aberrant arteries, the veins are rather unimportant. Hinman is of the opinion that following the plastic repair, drainage by means of nephrostomy and ureteral splint is usually the method of choice. The splint need not be left for more than seven to twelve days. Troublesome infection is negligible when urinary antiseptics are used.

In treatment of hydronephrosis caused by obstruction below the ureteropelvic junction (ureteral, vesical or urethral obstruction) removal of the obstruction which may be caused by stone, stricture, prostatism or posterior urethral valves usually suffices. Secondary changes, such as vesical diverticulum, ureterovesical stenosis or valve formation by an elongated tortuous ureter, may give rise to obstruction and require treatment.

Anomalies—Way and Popper² present a case of four urologic anomalies in which the patient was a soldier, 30 years old, who had died of postoperative complications after a gastric operation. The anomalies were (1) reduplication of the right kidney and ureter, (2) ectopic opening of the ureter from the upper segment of the right kidney into the right seminal vesicle, (3) aplasia of left kidney and (4) rudimentary segment of left ureter located between the left seminal vesicle and the ductus deferens.

Stones—Anderson³ found microscopic renal calculi in each of 170 diseased or grossly normal kidneys at necropsy. All the kidneys were

2 Way, R. A., and Popper, H. Four Urological Anomalies in One Person. *J. Urol.* 55:454-459 (May) 1946.

3 Anderson, L. Microscopic Renal Calculi, *Proc. Staff Meet. Mayo Clin.* 21:326-329 (Aug. 21) 1946.

removed from patients who had been more than 9 years of age at the time of death. Some of the calculi were located just under the epithelium at the tip of the papilla and some were noted to be ulcerating through this epithelium.

Since the work of Randall it has been fairly well accepted that some renal calculi are formed when the salts of the urine in the renal pelvis are deposited in layers on grossly visible plaques attached to the tip of the papilla. Perhaps these so-called Randall plaques were formed by the deposition of the salts of the urine on the nidus of these microscopic calculi.

Apparently almost every one has a microscopic calculus which could erode through the epithelium at the tip of the papilla and act as a nidus for the formation of a plaque and then a stone. It may be that some substance appears in the urine or blood which acts as a catalyst which causes the salts of the urine to be precipitated on the nidus or perhaps the unknown substance causes the epithelium to ulcerate and expose the tiny calculus to the salts of the urine. It is conceivable that the answer lies outside the kidney. The absence of some vitamin-like substances or the presence of some other known or unknown substance from the general metabolism of the body or from the diet might be a causative factor. In Anderson's opinion large or symptomatic renal calculi are the result of a systemic process or dietary disease rather than of a disease of the kidney.

Gersh and Meltzer⁴ state that xanthine calculi are surprisingly rare. Only 19 cases have been reported up to the present time. These authors report 2 cases in which the patients were soldiers aged 31 and 41 years respectively. The calculus from the first patient was a combination of calcium and xanthine, and the patient stated that he had been taking alkalis for one year to combat gastric hyperacidity. The prolonged production of alkaline urine probably created a favorable condition for the production of a xanthine-cation compound. In the second case the urine was persistently acid and the calculus was "pure" xanthine. The findings in this case confirm the fact that xanthine and other purine compounds are less soluble in acid than in alkaline solutions. The appearance of xanthine calculi at roentgenologic examination is apparently variable. In these 2 cases evidence of the calculi was not found at roentgenologic examination.

Dees⁵ discusses the reasons for incomplete surgical removal of renal calculi. A new technic for surgical removal of renal stones is described. The purpose is to insure more fully the complete removal of free renal

⁴ Gersh I and Meltzer H L. Xanthine Urinary Calculi. Report of Two Cases, *J Urol* 55 169-172 (Feb) 1946

⁵ Dees, J E. The Use of a Fibrinogen Coagulum in Pielolithotomy. *J Urol* 56 271-283 (Sept) 1946

stones, as well as to reduce the trauma to which the kidney is subjected at operation

An intrapelvic coagulum is formed by the simultaneous injection of thrombin and human fibrinogen into the renal pelvis. This coagulum theoretically incorporates within itself all free calculi present, regardless of size or location, and on withdrawal of the coagulum through a pyelotomy the stones are removed.

Within the limitations of the technic the results were excellent in 28 cases, partially satisfactory in 6 cases and unsatisfactory in 2 cases. Failure in 5 additional cases was attributed to technical difficulties.

Ellik⁶ presents a case of stone in the renal pelvis in which removal was accomplished by cystoscopy and use of the Balkus modification of the Zeiss looped catheter. The patient was a naval officer, 32 years old. The stone, which measured about 1.25 by 0.75 cm., was caught in the loop of the catheter in the renal pelvis and gradually brought down through the ureter in a five day period.

Tumors—Deming⁷ states that the prognosis in cases of malignant renal tumor is much poorer than is indicated by reports of five year follow-up studies. In his study of a series of 82 cases he found that 19.5 per cent of the patients lived five years, 14.6 per cent lived ten years, and 9.08 per cent were living without evidence of tumor at the time of his report. The fact that some died of the disease after the tenth year would indicate that even after ten years it cannot be assumed that a cure of a malignant renal tumor has been obtained.

The problems are manifold, embracing hereditary, congenital and acquired factors. Biologic proof, in addition to gross and microscopic evidence of malignancy in a renal tumor, must be obtained. Individual defensive measures on the part of the host against the development of renal neoplasms are probably a natural response. It is doubtful whether, in the so-called controlled cases in Deming's series, the malignancy of the tumors would have been proved by both the pathologic and biologic tests. Recovery of the patients can be explained in addition to surgical treatment, either on the basis of nonmalignancy of the tumor as proved by biologic tests or on the basis of natural factors of defense. Since surgical treatment and irradiation promise little other than control of less than 10 per cent of renal tumors, little improvement can be expected in the end results until some of the problems can be solved.

Hamm⁸ reports a case of angioma of the kidney in which the tumor was large enough to produce pyelographic evidence of a filling defect.

6 Ellik, M. Cystoscopic Transurethral Extraction of a Stone Located in the Renal Pelvis, *J Urol* 56:46-48 (July) 1946.

7 Deming, C. L. The Prognosis and Problems in Renal Tumors, *J Urol* 55:571-582 (June) 1946.

8 Hamm, F. C. Angioma of the Kidney, *J Urol* 55:143-148 (Feb) 1946.

which simulated that of papilloma of the renal pelvis. The patient was a white man, 34 years old, who complained of pain in the left renal region and gross hematuria. Cystoscopy and pyelograms revealed bloody urine from the left kidney and a small filling defect in the upper calix of the left kidney. Only the upper pole of the left kidney was removed because function of the right kidney was diminished. Subsequent pathologic examination revealed a small dark-colored tumor about 4 mm in diameter contiguous to a papilla of a posterior, superior calix and attached to the pelvic mucosa by a broad pedicle. Microscopic diagnosis was angioma.

Ney⁹ presents 10 cases of tumor thrombosis of the inferior vena cava associated with malignant renal tumors. These bring the total reported in the literature to 51. An analysis of the cases reported in Ney's paper substantiates the following previously stated facts. Renal tumors are by far the most common malignant tumors associated with tumor thrombosis of the inferior vena cava. The thrombus usually has extended from the renal vein (42 cases of the 51). In many of the cases (35) the malignant lesion was in the right kidney, probably because the renal vein on the right is short. Tumors occur predominantly in men (in 42 cases). Many (20) have extension of the thrombus into the right auricle.

In Ney's paper the following points are stressed, several are in disagreement with those stressed in other reports. Edema of one or both extremities is associated with thrombosis of the inferior vena cava so commonly that the diagnosis of tumor thrombosis can be made with a fair degree of certainty in cases of malignant renal tumors in which edema of the extremities is present. Direct invasion of the inferior vena cava is an important cause of thrombosis. The direction of the extension of the thrombus is not controlled entirely by the flow of blood. Patients with tumor thrombosis of the inferior vena cava appear to be seriously ill and rarely live more than six months after signs of obstruction have occurred.

Bandler and Roen¹⁰ report a case of testicular metastasis from hypernephroma of the kidney, such metastasis rarely occurs.

Unusual features of this case were that the testicular metastasis antedated the clinical detection of hypernephroma by two years; that this was a solitary metastatic lesion so far as could be ascertained; and that the patient was well three and one-half years after orchietomy and one year following nephrectomy. The testicular tumor was erroneously

9 Ney, C. Thrombosis of the Inferior Vena Cava Associated with Malignant Renal Tumors, *J Urol* 55 583-590 (June) 1946.

10 Bandler, C. G., and Roen, P. R. Solitary Testicular Metastases Simulating Primary Tumor and Antedating Clinical Hypernephroma of the Kidney. Report of a Case *J Urol* 55 663-669 (June) 1946.

believed to be a rare primary neoplasm in the two years which preceded the clinical recognition of the renal tumor

This case proves again that the presence of a solitary metastatic lesion is no contraindication to operation in hypernephroma

Metastasis in general and a possible mode of transmission in this case are discussed

Everett and Wavburn¹¹ report a case of diffuse infiltration of the renal pelvis and entire ureter by so-called Brunn's cell nests. In one portion of the kidney the picture presented was highly suggestive of extremely early squamous cell carcinoma. This would seem to indicate an etiologic role of such cell nests in the production of carcinoma as previously suggested by other investigators.

A brief review of the literature and a cursory examination of material in the Department of Pathology of the Johns Hopkins Hospital would suggest that subepithelial cell nests in the renal pelvis, ureter and bladder are by no means rare.

These findings may offer an explanation of the tendency of papillary tumors of the pelvis, ureter or bladder to be multiple and of malignant tumors of the pelvis or ureter to recur in any portion of the ureter not removed.

Pfeiffer and Gandin¹² state that massive perirenal lipoma must be considered in the diagnosis of immense abdominal tumors and included among those amenable to surgical treatment. This relatively uncommon, pathologically benign tumor, occurring more frequently in women, is characterized by insidious onset, tremendous enlargement of the abdomen, symptoms arising from pressure on neighboring structures, a tendency to malignant degeneration and recurrence after surgical removal, resulting in cachexia and death. If the tumor becomes malignant it usually becomes a fibroliposarcoma. True perirenal lipomas originate from the renal capsule or perirenal fat. However, they may arise from the mesentery or omentum. They are found most commonly in patients between the ages of 40 and 60 years. Diagnosis is made by means of pyeloureterograms in which distortion of the course of the ureter and dislocation of the kidney are considered to be diagnostic. Evidence of dislocation of the intestinal tract as seen on roentgenologic examination of the gastrointestinal tract may contribute to diagnosis. Treatment consists of surgical removal of the tumor. Nephrectomy is indicated when the kidney is intimately adherent to the tumor and when atrophy is present. The operative mortality rate is approximately 20 per cent. The ultimate prognosis is grave because recurrences are frequent and the recurrent tumors tend to undergo malignant degeneration.

11 Everett, H. S., and Wayburn, G. J. A Unique Case of Submucosal Epithelial Nests in the Ureter and Renal Pelvis, *J. Urol.* 56:310-318 (Sept.) 1946.

12 Pfeiffer, G. E., and Gandin, M. M. Massive Perirenal Lipoma with Report of a Case, *J. Urol.* 56:12-27 (July) 1946.

Pfeiffer and Gandin report a case of massive perirenal lipoma on the right in a 49 year old white man. The patient had noticed a feeling of fullness in the upper part of the abdomen for six months. The mass which weighed 26½ pounds (12 Kg) and the right kidney were successfully removed. Eleven months after the operation the patient was in apparently excellent health and felt well.

Pyelonephritis—Clark¹³ states that the physiologic changes in the urinary tract during pregnancy are loss of muscular tone, diminution of ureteral peristalsis, ureteral dilatation and hydronephrosis. The result of these changes is stasis which predisposes the upper part of the urinary tract to infection. Preexisting disease of the urinary tract increases the possibility of complications during pregnancy.

Preventive therapy is of utmost importance. To date the most effective bactericidal drugs are penicillin and the sulfonamide compounds. If drug therapy fails, if there is a history of preexisting renal disease or if the symptoms are unusual, cystoscopic examination, retrograde studies, differential cultures and pyelograms should be made.

Sterility of the urine must be obtained and then, if possible maintained throughout the remainder of gestation, delivery and the puerperium.

If the infection cannot be brought under control, termination of the pregnancy must be considered.

After delivery persistent infection and residual pathologic lesions of the urinary tract must be eradicated before further pregnancies.

Tuberculosis—Lazarus¹⁴ reports that a combination of deep roentgen treatment with ultraviolet radiation immediately after nephrectomy for tuberculosis almost completely eliminates postoperative formation of fistulas and disintegration of the wound. Also deep roentgen therapy to the bladder is a distinct aid in alleviating vesical pain and in promoting healing of tuberculous ulcerations.

Arteriography—Doss¹⁵ states that renal arteriography offers a visual estimation of renal function. Its value is striking in demonstrating the condition of the kidney above a completely or partially obstructed ureter. The large hydronephrotic kidney and the kidney filled with a staghorn calculus, often considered fit only to be removed, have been found, by the aid of arteriography, to be well worth saving.

¹³ Clark, W. D. Pyelitis of Pregnancy, *California Med* 65:21-26 (July) 1946.

¹⁴ Lazarus, J. A. Prevention and Treatment of Delayed Wound Healing and Ulcerative Cystitis Following Surgery for Tuberculosis of the Genito-Urinary Tract. *J Urol* 55:160-168 (Feb) 1946.

¹⁵ Doss, A. K. Translumbar Aortography. Its Diagnostic Value in Urology. *J Urol* 55:594-606 (June) 1946.

Renal arteriography is of little value in the diagnosis of squamous cell epithelioma of the kidney, the papillary type solely involving the pelvis or that which infiltrates the renal parenchyma. In the extensively infiltrated kidney the examiner is likely to find diminution in the arterial supply owing to the nature of the growth. In cases of hypernephroma or true adenocarcinoma pooling out of dye throughout the neoplastic mass in reticulated fashion is usually noted. These areas represent venous and arterial sinuses so frequently seen on sectioning such tumors. The intrarenal arteries are characteristically spread out in spider-like fashion. Simple solitary cysts are readily distinguished owing to lack or apparent lessening of arterial supply traversing the cystic cavity. Smaller multiple cysts, such as those present in early polycystic disease, are rather difficult to detect.

In cases of retroperitoneal tumor it is almost invariably possible to exclude or include the kidney as the origin because of the ease with which the renal arteries may be filled with radiopaque media.

Congenital or acquired renal ectopia in its various forms may be diagnosed easily by means of arteriography. With the assistance of the aortogram this diagnostic problem can be handled much more scientifically. The attenuation of the renal pedicle, pain and relative delay in emptying of the pelvis may well lead to the correct decision with respect to nephropexy. Usually the diagnosis of renal duplication, often only suspected when the excretory urogram or retrograde pyelogram is studied, is made relatively simple by aortography. In cases in which function in a segment of a duplicated kidney is either reduced or absent defective blood supply to this part frequently is discernible. With the arterial outline at hand when heminephrectomy is indicated, it is possible to make the incision in the kidney at a relatively avascular part allowing removal of the diseased portion with minimal damage. From a vascular and therefore functional standpoint, renal parenchyma is conserved precisely and consequently, and a more applicable operation is performed. Of all investigative measures employed, aortography is doubtless the procedure of choice for discovery of the rare case of Goldblatt hypertension. No patient who has unexplained hypertension has been examined completely without translumbar arteriography. Obstruction or occlusion of one of the renal arteries can most certainly be demonstrated. The removal of a kidney presenting such arterial encroachment by no means insures cure of the hypertension, for all too often the pathologic-physiologic process has become permanent in each kidney.

With rare exception the superimposition of an aortogram on a retrograde pyeloureterogram allows determination of whether or not an aberrant vessel is responsible for the hydronephrosis. Occasionally if an aberrant artery exists its lumen is obliterated and the artery cannot be visualized.

Renal Neurosurgery for Hypertension—Duff, Kenyon and Smith¹⁶ have used Smithwick's method of thoracolumbar sympathectomy in 10 cases of hypertension with encouraging results. They are of the opinion that the urologic surgeon possesses fundamental advantages in this field of surgery because estimation of renal function and evaluation of the structural integrity of the kidneys are important preoperative procedures. The surgical approach is retroperitoneal and the operation should include examination of the adrenal glands and biopsy of the kidney. They also discuss denervation of the renal artery for relief of nephralgia and in conjunction with nephropexy, pyeloplasty and nephrectomy. They state that denervation minimizes postoperative pain, prevents or diminishes reflex disturbances such as acute gastric dilatation, tympanites and adynamic ileus and in most cases obviates the pain of which the patient originally complained. The prerequisites for denervation of the renal artery are a readily mobilized kidney and an accessible renal pedicle.

URETER

Anomalies—Circumcaval ureter, also called 'postcaval ureter' and "retrocaval ureter," is a congenital anomaly in which the ureter passes behind the inferior vena cava. Goyanna, Cook and Counseller¹⁷ present a case of a man, 33 years old, who had suffered for three years with recurrent attacks of pain in the right side of the back, chills, fever, urinary frequency and dysuria, in which the diagnosis of right circumcaval ureter was made preoperatively by means of retrograde pyelography. At operation the right ureter was divided at the point of angulation about 3 inches (7.6 cm) below the ureteropelvic junction and about 1½ inches (3.8 cm) was excised. A V-shaped portion was excised from the proximal portion of the ureter to decrease its diameter, and an end to end anastomosis of the severed portions of the ureter was made over a splinting catheter. A nephrostomy tube was brought out through the lower calix of the kidney. On the thirtieth postoperative day the ureteral splint was withdrawn and on the thirty-ninth day the nephrostomy tube was removed. One year after operation the patient was feeling well and was free from symptoms. Goyanna, Cook and Counseller think that this anomaly may not be so rare as was formerly supposed, as 8 cases have been encountered since 1940 (5 were of clinical significance) while only 26 cases were reported from 1888 to 1940.

¹⁶ Duff, J., Kenyon, H. R., and Smith, K. F. Malignant Hypertension Neurosurgery of the Kidney, *J Urol* 55 153-158 (Feb) 1946

¹⁷ Goyanna, R., Cook, E. N. and Counseller V. S. Circumcaval Ureter Report of Case in Which Diagnosis Was Made Preoperatively. *Proc Staff Meet. Mayo Clin* 21 356-360 (Sept 4) 1946

Riba Schmidlapp and Bosworth¹⁸ report a case of ectopic ureter draining into the seminal vesicle and discuss the literature. In 23 of the 32 cases in which necropsy was performed the patients were between the ages of 6 and 73 years at the time of death, the average age was 48.3 years. This anomaly was present on the left side in 21 cases and on the right in 11. In 26 cases the ectopic ureter was single, and in 6 there was duplication. In 14 cases the corresponding kidney was rudimentary, and it was absent in 10. A double kidney was noted in 3 cases, fibrosis of the kidney, in 2, and cystic degeneration, in 2. In only 1 case was the kidney found to be normal at necropsy.

The distribution of these aberrant ureteral openings is of interest. The ureters in 22 cases drained into the seminal vesicles (18 into the left, 4 into the right) and in 10 cases, into the vas deferens or ejaculatory duct (7 into the right, 3 into the left).

The opening of an ectopic ureter into the seminal tract has been reported clinically four times. In two of these reports the ectopic ureter was a duplicated one and in two the ureter was single. One single and one duplicated ectopic ureter opened into the right seminal vesicle, while the remaining two opened into the left seminal vesicle. In all 4 cases, pyuria (intermittent in 2 and constant in 2) was the outstanding finding. In addition, 3 patients had pain, frequency, terminal hematuria and fever. One patient remained asymptomatic.

The case of a young man with a double left ureter is presented. The ectopic ureter drained into the left seminal vesicle. The source of the pyuria remained obscure for several months. The cloudy second glass of urine suggested disease of the seminal vesicle. Further roentgenologic examination after catheterization of the ejaculatory ducts simplified diagnosis. Complete excision of this anomalous left uretero-seminal vesicle cleared the urine permanently. Chemotherapy, including administration of penicillin, failed to remove the chronic infection.

Honke¹⁹ presents a case of ectopic ureter in a married woman 30 years old. Two ureteral openings in the right lateral vaginal wall approximately $2\frac{1}{4}$ inches (5.72 cm) and 3 inches (7.6 cm), respectively, from the orifice were the outlets of a common ureter leading from a small rudimentary renal pelvis located in the upper pole of the right kidney. This ureter apparently bifurcated about 5 cm from its vaginal termination. The condition was cured by heminephrectomy on the right kidney.

Ureterocele—Ortmayer, Koester and Stetler²⁰ present a case of prolapse of a ureterocele through the urethra in a woman, 64 years

18. Riba, L. W., Schmidlapp, C. J., and Bosworth, N. L. Ectopic Ureter Draining into the Seminal Vesicle, *J Urol* 56:332-338 (Sept.) 1946.

19. Honke, E. N. Ectopic Ureter, *J Urol* 55:460-463 (May) 1946.

20. Ortmayer, M., Koester, L., and Stetler, P. M. Prolapsus of a Ureterocele Through the Urethra, *J Urol* 55:515-519 (May) 1946.

old. She complained of something coming out of the vagina on straining for urination or defecation. The mass receded spontaneously when she was asleep or when it was pushed back. At cystoscopy a large ureterocele 2 to 3 cm in diameter, was found and it was determined that intermittent prolapse through the urethra occurred. The ureterocele was electrocoagulated, and ten months later cystoscopic examination revealed a large cuff of tissue, the proximal remnant of the ureterocele surrounding the right ureter. The patient was entirely free of symptoms.

Stones—Garvey and Gomberg²¹ compare the advantages and disadvantages of vaginal and abdominal ureterolithotomy. Disadvantages of the abdominal approach are: 1. The operation is difficult in obese patients and patients who have had previous operations on the lower part of the abdomen. 2. The ureter may be difficult to locate deep in the pelvis and may not be easily accessible. 3. The danger of shock is greater. 4. The abdominal incision presents the danger of postoperative hernia. 5. Convalescence is prolonged because drainage is poor and a postoperative febrile course with formation of abscess and fistula may follow. 6. The technic of the operation is difficult for the surgeon.

The comparative advantages of the vaginal approach are: 1. Obesity or previous abdominal scars provide no hindrance. 2. The ureter is located easily. 3. Little shock is associated with the procedure and abdominal contents are not manipulated. Local anesthesia may be used to minimize the danger of shock further. 4. An external incision is not made and there is no danger of postoperative hernia. 5. Convalescence is smooth, the hospital stay is short and drainage is dependent. 6. The operation is easier, less stripping of the ureter is necessary and impairment of the blood supply is minimal. Consequently, the danger of slough and formation of fistula is less.

The advantages of the abdominal approach are: 1. An incision can be made in the ureter above the point of impaction and the stone drawn up to the site of the incision for removal, if the stone slips away it can be moved up or down the ureter. 2. The incision can be enlarged to provide better exposure.

The disadvantages of the vaginal approach are: 1. If the stone slips up the ureter or is higher than anticipated, it cannot be drawn down. 2. The exposure is limited and the operation is difficult in nulliparas.

The authors state that the anatomy of the lower portion of the ureter makes it especially accessible from the vagina. In women the terminal portion of the ureter lies on the medial side of the uterine artery on the pelvic wall and turns forward and medianward below the posterior layer

²¹ Garvey, F. K. and Gomberg, D. Vaginal Ureterolithotomy, *J. Urol.* 56: 49-56 (July) 1946.

of the ligamentum latum uteri to the base of the urinary bladder, in so doing it runs through the parametrium, somewhat lateral from the cervix uteri. It then comes into direct contact with the anterior and lateral walls of the vagina, being crossed in front by the uterine artery at the level of the orificium internum ureteris. The prime prerequisites for vaginal ureterolithotomy are that the stone be palpable through the vaginal wall and that the patient be parous. It is impossible to expose the ureter for more than $2\frac{1}{2}$ inches (6.4 cm) above the ureterovesical junction.

The surgical procedure is as follows. The cervix is grasped with a tenaculum and retracted laterally in the opposite direction from the involved ureter. An incision about 1 inch (2.5 cm) long is made as far laterally as possible through the vaginal wall at the level of the cervix or directly over the stone if possible. A suture to be used for retraction may be placed through the upper edge of the incision, or suitable retractors may be used. The loose tissues are separated carefully with a curved hemostat until the ureter is seen, and the ureter is grasped above the stone with an Allis forceps, a longitudinal incision is made over the stone, and the stone is removed. After the stone is removed a bougie is passed up the ureter from the incision and also down through the intramural portion of the ureter to dilate it and prevent obstruction as a result of postoperative edema. The ureter is closed with one to three catgut sutures placed in the adventitia, and a small, soft rubber drain is inserted in the wound. Care must be taken to avoid placing it against the ureter. The incision in the vaginal wall is then closed. The drain is removed in twenty-four hours and the patient is allowed out of bed on the same day.

Garvey and Gomberg have carried out this procedure in 13 cases. The operation in 12 was successful and in 1 it failed. They state that the danger of ureterovaginal fistula is slight and that if no obstruction is present below the site of incision no fistula will form.

Trauma—Howard²² reports 8 cases of proved instrumental perforation of the ureter. The condition is probably more common than the small number of proved cases reported might indicate.

When the rent in the ureter is small and the ureter is not obstructed below it, there is ordinarily no untoward reaction and the patient readily recovers without surgical treatment. A serious condition may result if complicating urologic conditions occur or if the opening in the ureter is large enough to allow extravasation to occur and to continue in large amounts. Perforations by large instruments are more likely to be serious than those produced by small ones.

In itself, instrumental perforation of the ureter calls for observation rather than immediate surgical treatment. The time for drainage is determined by surgical judgment in the individual case. Most patients who recover without surgical intervention are either well or nearly well twenty-four hours after the injury.

²² Howard F S. Instrumental Perforation of the Ureter. *J Urol* 56:319-331 (Sept.) 1946.

PROSTATE

Hypertrophy—McCrea²³ reports a case of massive enlargement of the prostate in which the patient was a white man 88 years old who for the previous twenty-five years had had repeated episodes of acute urinary retention every six to twelve months. Each time retention was relieved by a single catheterization. The patient did not have additional symptoms sufficient to cause him to consider surgical relief. At necropsy the prostate and bladder were removed, they weighed 1300 Gm, substantiating the statement that, clinically, the size of the hypertrophied prostate rarely bears any relationship to the degree of symptoms produced.

Carcinoma—Wattenberg²⁴ reports a case of toxic hepatitis resulting from the giving of large doses of diethylstilbestrol for carcinoma of the prostate gland.

Other effects of diethylstilbestrol which occur during the treatment of carcinoma of the prostate gland are changes in the breast (dependent edema, reactions in the urethra, seminal colliculus and testes, and changes in the prostatic carcinoma). The presence of these changes is no index of the benefit which the patient receives from this treatment of the cancer of the prostate gland.

The change in the breast is extensive proliferation of the ductal epithelium. The ducts become elongated and budding is present. Edema of all the tissues is considerable and the connective tissue and vascularity are increased. Deposition of fat also can occur.

Often edema occurs while the patient is being treated with diethylstilbestrol. This edema usually occurs in the lower extremities and is due to a decreased renal excretion of sodium and chloride, which in turn causes water to be retained in the tissues. Consequently the volume of urine is reduced and thereby dependent edema is produced.

The change which takes place in the urethra is squamous metaplasia and considerable metaplasia and stratification of the epithelium of the seminal colliculus occur after therapy with diethylstilbestrol.

After treatment with diethylstilbestrol or any other estrogenic substance the testes show a thickened basement membrane of the seminiferous tubules with fibrous tissue. Often a rapid and advanced degree of atrophy of the testes can take place.

In the prostatic cancer before treatment with diethylstilbestrol most of its cells are arranged in acini. The cytoplasm is foamy and the nuclei located in the central portion of the cell are large and round and

²³ McCrea L. E. Massive Enlargement of the Prostate. *Am J Surg* 71: 284-286 (Feb) 1946.

²⁴ Wattenberg C. A. Life Changes and Other Effects of Diethylstilbestrol During Treatment of the Prostate Gland Cancer. *J Urol* 55: 631-640 (June) 1946.

contain rounded vacuoles. After the patient has taken diethylstilbestrol, the cytoplasm regresses, the nuclei become smaller, irregular and pyknotic, and no definite arrangement of cells is noted. In some portions there are no nuclei and only cell remnants are seen.

Lazarus²⁵ states that discrepancies between clinical and pathologic data in certain carcinomas of the prostate gland may be consequent of (a) failure of the pathologist to cut sections from an adequate number of tissue blocks and (b) failure of the pathologist to receive tissue from the part of the prostate harboring the malignant lesion.

Failure to remove the so-called false capsule of the gland in prostatectomy is the principal cause of failure to remove the carcinomatous portion. This may occur particularly in suprapubic or incomplete transurethral prostatectomy. The lesion is sometimes chiefly, if not entirely, confined to this portion of the gland. This holds true of prostates with large adenomas and with small malignant nodules.

Therefore, when a urologist, after thorough examination of his patient, surmises that he is confronted with carcinoma of the prostate gland, he should proceed with the accepted treatment of this disease, despite the contrary opinion of the pathologist. The surgeon will thereby reduce the patient's suffering and possibly prolong his life.

TESTIS

Tumors—Brewer²⁶ presents 2 cases of tumor of the testis. One was a teratoma and the other a seminoma. However, in each case the metastatic lesion was a choriocarcinoma. When each patient was examined first biologic tests for chorionic gonadotropin in the urine gave positive results. The writer concluded that chorionic tissue was present in the teratoma and seminoma, respectively, even though no chorionic tissue was identified in the sections examined microscopically. The chorionic tissues may not be demonstrated in the primary tumor because (1) it may be but a small part of the growth, (2) the entire tumor is not examined microscopically or (3) it is impossible microscopically to distinguish chorionic tissue from the multiple and varied tissues of a testicular tumor. In instances of teratoma, seminoma and such tumors, when the results of the test for chorionic gonadotropin are negative, choriocarcinoma does not coexist. If chorionic gonadotropin is present in the urine of a patient with a testicular tumor, it indicates the presence of choriocarcinoma even though chorionic tissue is not identified microscopically in the primary tumor.

25 Lazarus, J. A. Questionable Cancer of the Prostate Gland. *Clinical Versus Routine Pathologic Evidence*, J Urol 55 618-625 (June) 1946.

26 Brewer, J. I. Chorionic Gonadotropin in the Diagnosis of Testicular Tumors, Arch Path 41 580-591 (June) 1946.

Mathe²⁷ reports a case of lymphosarcoma of the testis in which the patient was a white man, aged 63 years. No evidence of metastasis was found at the time of orchiectomy. The tumor measured 6.5 cm in diameter. Three months later the tumor recurred at the site of the severed cord and multiple small nodular cutaneous metastatic lesions were found throughout the entire body. Mathe states that lymphosarcoma of the testis is extremely rare, usually occurs in the younger age group, is highly malignant and rapidly fatal. Treatment consists of (1) orchiectomy with radical removal or irradiation of the regional lymph areas or (2) irradiation alone. Surgical removal is the most desirable method when no evidence of metastasis is discernible. It is important to expose the cord at the external ring and to clamp and ligate the vascular pedicle early to prevent dissemination of malignant cells. Severing the vas deferens as high as possible is a further valuable precautionary measure against extension. The wound is bathed in alcohol to destroy any tumor cells that might have escaped.

Scheetz and Leddy²⁸ state that teratoma is a tridermic tumor in which one or more of the components may undergo malignant degeneration and estimate that about 1 of every 10,000 males admitted to a hospital will have a malignant teratoma of the testis. They report therapeutic results in 54 cases of malignant teratoma observed at the Mayo Clinic and conclude that roentgen therapy does not seem to have any beneficial effect in cases of malignant teratoma, which is extremely resistant to roentgen rays. The only manner in which a cure can be obtained is by orchiectomy before metastasis has occurred. This can be attained in less than a third of cases. After metastasis has occurred death usually follows within eighteen months.

Auerbach, Brines and Yaguda²⁹ report a study of cases of neoplasm of the testis. In a United States naval hospital designated as a cancer center for naval personnel, in which one hundred and fifty beds are allotted to the tumor service, necropsy was performed in 26 cases of malignant tumor of the testis in a period of three years. 22 of these being encountered in the last two years. These 26 cases represented 20 per cent of all cases of malignant disease in which necropsy was performed at this hospital during this period.

Seventy-three per cent of all patients were in the third decade.

Treatment in 23 cases consisted of simple orchiectomy and high voltage roentgen therapy in the regions of metastasis.

²⁷ Mathe, C. P. Lymphosarcoma of the Testicle. Report of a Case, *J. Urol.* 55: 530-541 (May) 1946.

²⁸ Scheetz, R. J., and Leddy, E. T. Roentgen Therapy for Malignant Teratoma of the Testis, *Am. J. Roentgenol.* 55: 754-764 (June) 1946.

²⁹ Auerbach, O., Brines, O. A., and Yaguda, A. Neoplasms of the Testis, *J. Urol.* 56: 368-374 (Sept.) 1946.

The average duration of life after the institution of treatment was eleven months. No patient lived more than twenty-two months after the diagnosis was made.

Trauma did not appear to play an important etiologic role in this series of cases.

The distribution of metastatic lesions followed a uniform pattern in nearly all cases, the four principal secondary sites being, in order of prevalence, retroperitoneal lymph nodes, lungs, mediastinal lymph nodes and liver.

Varicocele—Beneventi³⁰ states that varicocele is a varicosity of the pampiniform plexus and should be considered as detrimental a condition for the testis as varicose veins are for the lower limbs. He reports the surgical treatment in 28 cases. The object of the treatment was prevention of venous backflow into the pampiniform plexus by ligation of the internal spermatic vein in the inguinal canal at the internal ring. A 3 inch (7.6 cm.) inguinal incision is made slightly above and parallel to Poupart's ligament. The skin, subcutaneous tissue and Scarpa's fascia are incised and retracted from the underlying external oblique aponeurosis. The external ring and the cord emerging from it are identified. An incision is then made in the aponeurosis along the course of its fibers beginning at a point about 1 cm. lateral to the ring, thereby leaving the arcuate fibers of the external ring intact. The cut edges of the external oblique muscle are retracted and the inguinal canal and its contents are exposed. The cremasteric muscle is then incised and the elements of the cord are separated. In order to preclude injury to the vas deferens and the internal spermatic artery, these structures are first identified and retracted out of the field of operation. The enlarged and distended internal spermatic vein or veins are easily identified and bluntly separated from the surrounding structures. Careful search is then made for a hernial sac in the region of the internal ring, and if one is found high ligation and excision are then carried out. If some slack is found in the transversalis fascia, this is taken up with two or three sutures. The transversalis fascia and the conjoint tendon are then sutured to the shelving edge of Poupart's ligament. Kocher clamps are then placed on the offending veins and a 1 inch (2.5 cm.) segment of vein is excised. The stumps are ligated and the ends are bound together. A needle is then threaded with the long ends of the ligature and the obliterated veins are sutured to the under surface of the internal oblique muscle. The elements of the spermatic cord are then repositioned on the newly constructed floor of the inguinal canal, and the cut edges of the external oblique aponeurosis are either approximated or imbricated. If hernial repair has been necessary the patients remain in bed for six days; otherwise they are up on the second or third postoperative day.

30 Beneventi, F. A. Varicocele, *Am J Surg* 71:783-787 (June) 1946.

Beneventi makes the following observations: 1 The internal spermatic vein was often doubled or bifurcated. 2 The internal spermatic artery (a branch of the abdominal aorta) was closely associated with the veins in the cord and great care must be exercised to avoid injuring it. 3 The external spermatic artery (cremasteric) a branch of the inferior epigastric artery, is distributed in the elements of the sheath of the spermatic cord. It is the chief source of bleeding when the cord is manipulated. 4 A small indirect incomplete hernial sac was found in 8 cases. Seven of the 8 patients were between the ages of 25 and 31 years. All had large varicoceles which had been present from five to twelve years. 5 The external ring was always intact unless it was unduly relaxed.

The postoperative course is short, and testicular tenderness is present temporarily. Beneventi concludes that a satisfactory operation without disturbing complications can be assured in almost every case of varicocele treated by the method which he describes.

TORSION OF THE SPERMATIC CORD

Riba and Schmidlapp³¹ discuss torsion of the spermatic cord and present 5 cases. The patients were young soldiers. The authors state that if a history of acute excruciating pain in the testis is obtained from a patient who does not have infection of the urinary tract the physician should suspect that acute torsion of the cord has occurred. The pain may follow any type of muscular effort or exertion and is usually most severe during the first twenty-four hours, and after forty-eight to seventy-two hours it will spontaneously begin to subside. Riba and Schmidlapp state that if a history of recurrent pain in one or both testes is obtained and the patient is less than 20 years old the presence of chronic recurrent torsion of the cord should be suspected especially when infection is absent. In acute cases swelling, edema and tenderness of the involved testis are noted. Elevation of the testis may aggravate the pain if torsion has occurred (Pregn's sign), whereas it usually tends to relieve the pain of acute epididymitis. The contents of the involved scrotum may be fixed to the adjacent coverings (Dillon's sign). In cases of neglected torsion of the spermatic cord the outstanding findings are the rubbery firm, smooth testis which is elevated and retracted against the external inguinal ring. In late cases the testis becomes smaller and asymptomatic and finally it atrophies completely. It is extremely important to make a diagnosis early if the testis is to be saved. Surgical detorsion may be possible and should be followed by orchiopexy to preclude subsequent attacks. In acute torsion an operation is performed immediately or within eight hours; the organ will usually remain viable. Riba and Schmidlapp are of the

³¹ Riba, L. W. and Schmidlapp, C. I. Torsion of the Spermatic Cord. Surg., Gynec. & Obst. 83 163-170 (Aug) 1946

opinion that many testes could be saved if exploration were carried out in a few cases of acute epididymitis in which a mistaken diagnosis of torsion had been made rather than treatment of the majority of acute torsions conservatively as epididymitis

EPIDIDYMIS

Tumors—Sworn, Marshall and Edwards³² report 2 cases of tumor of the epididymis. On microscopic examination each tumor showed a fibrous capsule containing plain muscle fibers. Within the capsule the tissue consisted of tubules lined by a single layer of flattened and cubical cells with rounded and vesicular nuclei. No mitotic figures were observed. The tumors measured 2 by 2.2 cm. and 1.7 by 1.25 cm., respectively, and were concluded to be of the benign "adenomatous" type.

PENIS

Tumors—Melicow and Ganem³³ state that penile neoplasms are found almost exclusively in uncircumcized patients. Although the neoplasms should be discovered early because the penis is one of the most frequently handled parts of the body they are often well advanced and frequently have metastasized by the time the diagnosis is made. The delay in establishing a diagnosis is apparently due to the fact that the tumor grows insidiously within an enclosed preputial cavity which has already given the patient prolonged trouble with infection, edema and retention of secretions. Penile cancer represents about 2 per cent of all malignant lesions in the male. It is almost unknown among Jewish men. The writers are of the opinion that the chronic irritation in cases of phimosis and chronic balanoposthitis probably gives rise to development of some carcinogenic agent or agents, possibly altered smegma or a virus or both. The majority of penile cancers develop on the glans at the corona or sulcus, and are usually squamous cell epitheliomas. Precancerous lesions which occur are leukoplakia, erythroplasia of Queyrat, Paget's disease and Bowen's disease.

The majority of penile neoplasms appear either as a papillary excrescence or as an induration which is usually ulcerated and proves refractory to local treatment. Early lesions are painless, however, later, when ulceration and secondary infection develop, there may be pain and bleeding. The inguinal lymph nodes tend to become enlarged as the result of inflammatory or neoplastic changes secondary to the penile lesion. Lymphatic drainage occurs through a deep and superficial system. The lymph nodes of the skin and subcutaneous tissue drain

32 Sworn, B. R., Marshall, F. W. and Edwards, J. L. Solid Tumors of the Epididymis, *Brit J Surg* 33 375-377 (April) 1946.

33 Melicow, M. M., and Ganem, E. J. Cancerous and Precancerous Lesions of the Penis. A Clinical and Pathological Study Based on Twenty-Three Cases. *J Urol* 55 486-514 (May) 1946.

into the superficial inguinal nodes. Those of the glans penis and urethra drain into the deep inguinal nodes and external iliac nodes of the pelvis. Some lymphatics may drain directly into the external iliac lymph nodes without joining the inguinal nodes. Microscopic evidence of metastasis to inguinal nodes may be found even though the glands cannot be palpated. Metastasis by way of the venous system may occur. Distant metastatic lesions may be found in the bony pelvis, prostate, lungs, spleen, mediastinal glands, skull and brain.

Regarding treatment, there should be no undue delay between diagnostic biopsy and operation. Type of treatment may vary from simple circumcision to radical amputation with dissection of the lymph nodes. Routine dissection of the inguinal lymph nodes is probably the procedure of choice in all cases, however. Factors to be considered in the choice of treatment are (1) the patient's age, (2) the size of the lesion, (3) the nature of the lesion, that is, whether papillary or ulcerative, (4) involvement of the superficial lymphatic channels of the penis, (5) extension through Buck's fascia into the corpora cavernosa of the penis, (6) the presence or absence of palpable inguinal lymph nodes, (7) the degree of superimposed infection, and (8) coincident presence of other disease and general condition of the patient. Opinion regarding the use of postoperative irradiation differs, and Melicow and Ganem have observed no lasting benefit.

STERILITY

Tompkins³⁴ states that complete study of male sterility must include an accurate sperm count. The most acceptable specimen is one which is obtained by means of masturbation and is collected in a clean glass container. Specimens obtained in a condom are unsatisfactory for two reasons: chemicals in the rubber or in the talc devitalize some of the sperms and an indeterminate number of sperms adhere to the penis. Withdrawal specimens are also unreliable. Fractional counts show that as many as 75 per cent of the total number of sperms may be contained in the first third of the semen ejaculated. If any of the specimen is lost before withdrawal, as frequently happens, it will be the first portion which contains most of the sperms. Therefore all who have studied male infertility agree on the necessity of masturbation in obtaining specimens for accurate counts.

In making the sperm count at least two specimens must be studied before formulation of an opinion is justified. A differential count and a test of the duration of motility must be included. Normal semen contains 100,000,000 or more sperms per cubic centimeter and 80 per cent of the spermatozoa are morphologically normal. A count of

³⁴ Tompkins, P. Medical Progress. Current Methods for the Study and Treatment of Sterility. *California Med* 65:76-80 (Aug) 1945.

less than 60,000,000 indicates relative infertility. The degree of fertility is roughly directly proportional to the count. If complete absence of sperms in the semen is found, testicular biopsy should be carried out to distinguish between failure of spermatogenesis and vasoepididymal occlusion.

URETHRA

Anatomy—Deter, Caldwell and Folsom³⁵ state that knowledge of the embryology of the female urethra is meager.

Krenchevsky's research indicates a definite homology between the prostatic urethra of the male and the posterior portion of the urethra of the female.

Periurethral glands were found to be present in 92 per cent of 100 urethras studied. A majority of glands were found to be lateral and posterior to the urethra, and the distribution was approximately the same as that found in the male prostatic tissue. The closer to the bladder the sections were taken, the greater the number of glands found.

The role played by periurethral glands in harboring infection and distributing it to the upper part of the urinary tract is again emphasized.

The pathologic findings are tabulated, and it is concluded that the number of glands in the posterior portion of the urethra, beyond a certain point, is not a factor in harboring infection. A certain degree of glandular development seems to have a definite relationship to the development of posterior urethritis in females.

Urinary Extravasation—Howland³⁶ reports a study of 60 cases of urinary extravasation. In previous studies, the mortality rate has ranged up to 50 per cent and beyond, except for one small series in which Ockerblad and Carlson reported 1 death in 15 cases encountered in a period of ten years.

Howland considers that urethral abscess and urinary extravasation are two stages of the same process. If urine is extravasated below Buck's fascia, periurethral abscess is present; if urine is extravasated beyond this barrier, the condition is called "urinary extravasation."

Howland's 31 cases of urinary extravasation and 29 cases of periurethral abscess were encountered at Grady Hospital during the last two years. The high incidence of gonorrhea in the Negro, together with the neglect and improper treatment of the original urethritis, makes the incidence of urinary extravasation higher at that hospital than at other institutions. All except 2 of the patients were Negroes, and the majority were in the age group of 30 to 50 years. The range was from 18 to 69 years.

35 Deter, R. L., Caldwell, G. T. and Folsom, A. I. A Clinical and Pathological Study of the Posterior Female Urethra, *J. Urol.* **55**: 651-662 (June) 1946.

36 Howland, W. S. Urinary Extravasation. A Study of Sixty Cases, *J. Urol.* **56**: 387-391 (Sept.) 1946.

The etiologic condition was urethral stricture in 49 cases while in 2 it was undetermined. In the remainder the various causative factors included urethral stone, gunshot wounds, external trauma, use of sounds and catheterization.

The diagnosis of extravasation is relatively easy if careful examination of the genitalia and perineum is made. The onset of periurethral abscess is gradual. The abscess begins as a swelling in the perineum which is tender, nonfluctuant and well localized. Occasionally, pressure on the abscess will extrude pus from the urethra.

In urinary extravasation pronounced swelling of the scrotum and the penis usually is present, and sometimes the anterior abdominal wall is swollen. Little or no tenderness is noted, but the skin pits easily. Discharging sinuses may be present if the extravasation has continued for a long time. The patient always looks much sicker than one who has periurethral abscess, and jaundice may be present. Contrary to previous reports, knowledge of the patient's temperature was of little value in differentiating the two conditions. In Howland's series, the temperature curves were about the same in the two conditions. Temperatures ranged up to 104° F. These conditions are frequently mistaken for perianal abscess, epididymitis and obstructive phimosis. Also many cases of massive edema due to congestive heart failure are called extravasations.

The duration of the condition varied, the average was from one to five days. In some cases it was as long as two weeks. The duration had little relation to mortality, although when the disease was of long duration recovery took more time.

The majority of the organisms in these conditions are sensitive to sulfonamide compounds and penicillin. The decided drop in mortality rate which Howland notes is probably based on that fact. In 19 cases staphylococci were found, in 19, streptococci and in 4, *Escherichia coli*.

The method of treatment now used at Grady Hospital consists of immediate drainage of the infected portions and diversion of the urinary stream. This is accomplished by means of suprapubic cystostomy and multiple incisions and drainage. Perineal urethrotomy was not found to be feasible because of the associated stricture which occurred in almost all of Howland's cases. In several the entire anterior abdominal wall was incised down to the external oblique aponeurosis. The incisions were connected by Penrose drains. In periurethral abscess pus usually is not found until Buck's fascia has been opened. The abscess cavity is then packed with iodoform gauze packs. If the patient has a high temperature or if symptoms of toxemia occur administration of the sulfonamide compounds is started immediately and a transfusion of whole blood or plasma is given. When the urethra has been dilated and allows passage of a 24 F. catheter the catheter is removed and the suprapubic sinus is allowed to close. The patient

returns weekly for passage of sounds for about three months, and after that at least four times a year

In Howland's series, suprapubic cystostomy was performed in 51 cases. In 6 cases treatment consisted of perineal urethrotomy or dilatation of the urethra and catheterization. But he observed that the conditions tend to recur and it is necessary to perform suprapubic cystostomy at a later date.

The length of the hospital stay was considerably shorter than has been reported. More than half (35) of the patients were dismissed in the first two weeks after operation. Five of the 65 patients died.

SEMINAL VESICULITIS

Seabaugh³⁷ reports 2 cases of acute congestion of the seminal vesicles which exhibited symptoms of acute disease of the lower part of the abdomen. Both patients were young men in the navy. While in the United States their sexual activity had been extensive. When they were transferred to a small tropical island base they had neither intercourse nor nocturnal emission from the time of their arrival to the date of their admission to the hospital, a period of about three months. One patient had pain in the right lower quadrant of the abdomen and was operated on for appendicitis. However, the appendix was normal and the pain persisted postoperatively. Seven days after operation rectal examination revealed that both seminal vesicles were enlarged markedly and that the right one was tender. By means of massage 10 cc of gelatinous secretion containing pus, grade 2 plus, was removed. The pain was relieved and did not return following the massage. The second patient had pain in the left lower abdominal quadrant, and examination revealed bilateral enlargement of the seminal vesicles. The left one was especially tender. Six cubic centimeters of gelatinous secretion containing pus, grade 3 plus, was removed by means of massage. The abdominal pain disappeared immediately after the first massage.

PYELITIS, URETERITIS AND CYSTITIS CYSTICA

Kopp³⁸ states that the chief complaints of patients who have ureteritis and cystitis cystica are of pain in the lumbar region of long duration, frequently of chills and fever and often of nausea and vomiting. On physical examination costovertebral tenderness of the involved side is usually present. The condition usually is associated with chronic infection of the urinary tract, and stones are frequently present.

37 Seabaugh, D. R. Seminal Vesiculitis (Congestive) Simulating Acute Abdominal Disease, *J Urol* 55 173-178 (Feb) 1946

38 Kopp, J. H. Pyelitis, Ureteritis and Cystitis Cystica, *J Urol* 56 28-34 (July) 1946

On cystoscopic examination the trigone is seen to be covered with many small translucent cysts and the ureteral orifice of the involved side or sides is usually edematous and reddened. The urethral catheter meets with obstruction which is temporary because the cysts are ruptured as the catheter is passed. This rupturing may cause the passage of some blood around the catheter, which is significant of ureteritis cystica. Relief of pain after passage of the catheter is also diagnostic. The appearance of dye may be delayed, but renal function usually is not impaired. The characteristic appearance of the lesion on roentgenologic examination is diagnostic. The filling defects in the ureter, usually in the upper two thirds, give the ureter a bubbly or frothy appearance. These defects easily can be mistaken for nonopaque calculi or air bubbles. Evidence of any coexistent renal disease will also be seen at this time.

Treatment consists of dilating the ureter, thereby rupturing the cysts, and instillation of silver nitrate to destroy the traumatized cysts by its astringent action. Successful treatment of the lesion with sulfathiazole has been reported.

Kopp reports 3 cases of ureteritis cystica. Two of the patients were men, aged 60 and 23 years, respectively, and 1 was a woman, 59 years old. The condition of the younger man was treated successfully by means of ureteral dilations and silver nitrate.

Arduino³⁹ reports a case of pyelitis and cystitis cystica in a white man, 55 years old. On cystoscopic examination marked cystic changes over the trigone were observed and retrograde pyelograms revealed that the calix of each kidney was somewhat dilated and had a mottled appearance. These abnormalities were considered to be due to small cystlike structures in the calices. Results of guinea pig inoculation were negative for tuberculosis. *Alcaligenes faecalis* was cultured from urine from the left kidney. The patient's symptoms of nocturia, frequency, urgency and hesitancy ceased when sulfathiazole was administered, pyuria was decreased and renal function was improved notably. Arduino reports that the cystic disease in this case was due to a chronic inflammatory process and that this condition may be present in cases of carcinoma calculi associated with infection, ureteral obstruction, schistosomiasis and possibly with excretion of toxic substances through the urinary tract.

ANTIBACTERIAL AGENTS

Sulfonamide Drugs—Flippin and his associates⁴⁰ report the use of both sulfadiazine and sulfamerazine in 54 cases. Crystals were found

39 Arduino L J. A Case of Pyelitis and Cystitis Cystica. *J Urol* 55 140-152 (Feb) 1946.

40 Flippin H F, and Reinhold I G. An Evaluation of Sulfonamide Mixtures and Various Adjuvants for Control of Sulfonamide Crystalluria. *Int Med* 25 433-442 (Sept) 1946.

in 6 per cent of the urine specimens when the mixture was administered at the rate of 4 to 6 Gm daily, equal parts of each drug being used. The patients received no alkali or other adjuvant. This incidence of crystals was the same as that found in a group of patients who received a parallel dose of either sulfadiazine or sulfamerazine alone and 12 Gm of sodium bicarbonate daily. When only 6 Gm of sodium bicarbonate was used the incidence of crystalluria was increased to almost four times that when sulfadiazine or sulfamerazine was administered alone.

Because of the inadequacy of alkalinization and water diuresis in the prevention of the formation of crystalline deposits of sulfonamide drugs in the kidneys, Lehr⁴¹ experimented with the use of sulfonamide mixtures instead of single compounds as a method of combating this hazard. He concludes that the use of sulfonamide mixtures should add considerably to the protective action of alkalinization and forcing of fluids. It was found that two or more sulfonamide compounds, if present simultaneously in water or urine, did not influence each other with regard to their particular solubilities. A saturated aqueous solution or urinary solution of sulfathiazole could still be fully saturated with sulfadiazine and sulfamerazine. The antibacterial activity of a combination of sulfathiazole and sulfadiazine (in equal amounts) corresponds largely to the total concentration of free sulfonamide compounds. In many instances it was found that the mixture was even more effective than the the same total concentration of either drug alone.

Therapeutic studies with a mixture containing equal parts of sulfathiazole and sulfadiazine were carried out under carefully controlled conditions in 70 unselected cases of acute bacterial infections. Special consideration was given to daily follow-up studies of the concentration of the sulfonamide compounds in blood and urine, to the frequency of occurrence of sulfonamide crystals in the urine and its relationship to the urinary p_H and to any signs or symptoms of renal complications. Treatment consisted in the oral administration of the combination of sulfathiazole and sulfadiazine, 4 Gm initially (2 Gm of sulfathiazole plus 2 Gm of sulfadiazine) and then 1 Gm of the combination every four hours day and night, and decreased to 1 Gm every six hours when defervescence and other clinical signs indicated significant improvement. A minimal fluid intake of 3,000 cc in twenty-four hours was maintained. In almost all cases in this series the therapeutic response was highly satisfactory. Defervescence and general clinical improvement seemed to occur with greater speed than when either of the drugs were administered separately. Crystalluria was encountered in but few instances despite the almost constant presence of high concentration of the sul-

41 Lehr, D. The Prevention of Renal Complications by the Therapeutic Employment of Sulfonamide Mixtures. I. Sulfathiazole-Sulfadiazine Combination. *J. Urol.* 55: 548-566 (May) 1946.

fonamide mixture in acid urine. In none of the cases was there any evidence of renal irritation, such as hematuria, casts or oliguria.

This series, although too small for a conclusive evaluation, was conspicuous because of the unusual speed in the therapeutic response in many instances and also because of the almost complete absence of toxic effects. Persistent and massive crystalluria observed so frequently in treatment with sulfadiazine and especially with sulfathiazole was not encountered despite the intentional omission of adjuvant alkali therapy. It is common knowledge that the incidence of crystalluria is much higher than the incidence of discernible renal irritation. Lehr is of the opinion that it is primarily the mechanical factor of intratubular deposition of poorly soluble crystals rather than a primary chemical nephrotoxic action which accounts for most renal complications of sulfonamide therapy.

Penicillin—Mathe⁴² reports on the use of penicillin as an adjunct to genitourinary surgery, stating that it is often a lifesaving measure in the aged patient who has disease of the prostate and is sensitive to the sulfonamide compounds. The importance of penicillin is enhanced by its bacteriolytic effect on staphylococci which have proved refractory to sulfonamide therapy. In 8 of the 11 cases reported the surgical risk was poor because overwhelming mixed urinary infection was present. Penicillin therapy, instituted prophylactically in 6 and therapeutically in 5, controlled infection and hastened the patient's return to health in all. Mathe states that in this group of cases penicillin has surpassed any other chemotherapeutic agent formerly used. Acute infections with organisms susceptible to treatment with penicillin are readily controlled by intramuscular administration of 20,000 units every four hours until a total of 300,000 to 500,000 units has been given. Patients who have chronic mixed infections are benefited by destruction of susceptible organisms, however, response is slower and total doses of from 2,000,000 to 3,000,000 units are required. Mathe also recommends lavage of surgical wounds with 250 units of penicillin per cubic centimeter of isotonic solution of sodium chloride and states that the wider use of penicillin in operative wounds offers great promise.

Streptomycin—Pulaski⁴³ states that streptomycin shows its most important action against gram-negative organisms including *Escherichia coli*, *Proteus vulgaris*, *Aerobacter aerogenes*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. It is also potent against gram-positive cocci especially nonhemolytic streptococcus. Concentrations of from 500 to 2,000 micrograms of streptomycin per cubic centimeter of urine can be achieved by restricting the fluid intake to 2,500 cc per day and admin-

⁴² Mathe, C. P. Penicillin Therapy as an Adjunct to Genitourinary Surgery. *Am J Surg* **71**: 233-241 (Feb.) 1946.

⁴³ Pulaski, E. I. Streptomycin in Surgical Infections. II. Infections of the Genito-Urinary Tract. *Ann Surg* **124**: 392-401 (Aug.) 1946.

istering 0.4 Gm of the drug intramuscularly every four hours. These concentrations are sufficient to sterilize the urine in most cases when the bacteria are susceptible and when no complicating factors are present. Usually therapy for three days is adequate. The action of the drug is greatest in alkaline mediums. Cases in which treatment is to be given should be selected carefully on the basis of bacterial susceptibility to streptomycin, adequate renal function and absence of obstruction or calculi in the urinary tract. Successful therapy depends on susceptibility of the bacteria, a free flow of urine and adequate dosage. Pulaski treated infections of the urinary tract at the Halloran General Hospital. Eight patients who had paraplegia due to injury of the spinal cord were treated with streptomycin after treatment with penicillin and sulfonamide drugs had failed. In 3 cases streptomycin effected a prompt and lasting sterilization of the urine. In 13 cases of nonvenereal infections of the urinary tract the results were good in 7, fair in 1 and doubtful in 4, in 1 treatment failed.

Cook, Greene and Hinshaw⁴⁴ report on the use of streptomycin in 12 cases of genitourinary tuberculosis. The youngest patient was 8 years of age, the oldest, 51 years. Eight patients had tuberculous cystitis with tuberculosis in a solitary kidney, the other having been removed previously because of tuberculosis. The remaining 4 patients had bilateral renal tuberculosis and tuberculous cystitis. Streptomycin was administered intramuscularly every three or four hours, and most of the patients received at least 1 Gm daily. The shortest period of therapy was thirty-one days, and 1 patient was still receiving streptomycin at the time the report was written, two hundred and fifty-four days after therapy was begun. The writers report the following therapeutic results: (1) alleviation of the vesical symptoms in some cases, (2) decrease in the degree of pyuria, (3) decrease in incidence of positive staining for *Mycobacterium tuberculosis* in the urine and (4) improved cystoscopic appearance of the bladder. The genitourinary tuberculosis of 2 patients was apparently arrested, for the results of inoculation of guinea pigs formerly reported positive became negative. Cook, Greene and Hinshaw emphasize that streptomycin is not a substitute for surgical treatment in most cases of tuberculosis of the urinary tract. However, its therapeutic effects are encouraging.

Methenamine Mandelate—Carroll and Allen⁴⁵ discuss the treatment of urinary infections with methenamine mandelate. In 200 cases of com-

44 Cook, E. N., Greene, L. F., and Hinshaw, H. C. Streptomycin in the Treatment of Tuberculosis of the Urinary Tract, *Proc. Staff Meet., Mayo Clin.* 21: 277-280 (July 24) 1946.

45 Carroll, G., and Allen, H. N. The Treatment of Urinary Infections with Mandelamine (Methenamine Mandelate). A Clinical Study of Two Hundred Cases, *J. Urol.* 55: 674-681 (June) 1946.

mon urinary infections the drug has proved to be effective in 147 (approximately 74 per cent). When methenamine mandelate was given, the average time required to sterilize the urine was six days, although some conditions, such as pyelitis, were favorably affected in three days, whereas in infections associated with deep-seated or obstructive lesions, as long as two weeks were required before favorable response was obtained.

Methenamine mandelate was found to be virtually nontoxic in therapeutic doses. Mild untoward symptoms which might be attributed to the drug occurred in less than 3 per cent of the cases.

The administration of methenamine mandelate maintained an acid urine without dietary restriction or other drug therapy, except in those cases in which urea-splitting organisms were present. In these cases (4 per cent of the cases in the series) the urine remained alkaline despite an acid-ash diet and administration of ammonium chloride.

From this study it is evident that methenamine mandelate is an efficient urinary antiseptic of low toxicity and broad therapeutic activity in urinary infections. Its nontoxic nature and effective antibacterial action against the organisms most frequently encountered in the urinary tract establish this drug as a valuable agent for controlling common urinary infections.

UROGRAPHY

Kearns, Hefke and Morton⁴⁶ report on the use of bis-diethanolamine N-methyl-3,5-diiodo-chelidamate, a new excretory urographic medium. The medium was injected one thousand two hundred and eighty times in 1,232 cases. Reactions and diagnostic value of the resulting roentgenograms were recorded in 915. After preliminary catharsis and a night of fasting, each patient was given an injection of 30 cc of a 67 per cent solution of this medium.

Evidence of toxicity was carefully investigated in one group of 10 cases in which tests were carried out before injection and after injection of "neo-iopax" N N R and bis-diethanolamine N-methyl-3,5-diiodo-chelidamate. Each patient received alternate injections of the two preparations approximately one week apart. Studies of the chemistry of the blood, including determination of levels of nonprotein nitrogen, sugar and chlorides, were made. In no instance were significant changes in the urine demonstrated after injections. In each instance the patient received the two different injections under identical conditions and the technical setup was exactly duplicated. Consequently the density and detail were the same in the two roentgenograms.

The authors conclude that bis-diethanolamine N-methyl-3,5-diiodo-chelidamate is a safe and satisfactory excretory urographic medium.

⁴⁶ Kearns W M, Hefke, H and Morton S A. Ditopax—a New Excretory Urographic Medium. A Clinical Report on 1,280 Injections. J Urol 56:392-398 (Sept.) 1946.

In 75 per cent of the 915 cases no untoward reactions were encountered. In the remaining 25 per cent the reactions were largely inconsequential.

The value of bis-diethanolamine N-methyl-3,5-diiodo-chelidamate in roentgenographic diagnosis compares favorably with that of the other commonly used mediums.

It is their opinion, based on observation of a small series of cases, that the diagnostic value is rated in the following order: "neo-iopax," bis-diethanolamine N-methyl-3,5-diiodo-chelidamate and "diodrast." N N R

In their opinion after numerous injections of each preparation bis-diethanolamine N-methyl-3,5-diiodo-chelidamate causes definitely less pain in the arm than "neo-iopax" and less systemic reaction than "diodrast."

Florence, Howland and Weens⁴⁷ made intravenous urograms in 23 cases while the patients were having episodes of acute renal colic. In 12 calculi were found to be the cause of renal colic. In the remaining cases ureteral stricture, kinking of the ureters and congenital anomalies of the urinary tract were considered as etiologic factors. In 1 case urographic findings were not abnormal.

Intravenous urography gave information far more valuable than that obtained from survey roentgenograms. The urograms were most valuable in identifying opaque calculi or indicating the presence of ureteral obstruction. They contributed significantly to the diagnosis of renal colic and early clarification of its causation by giving positive information in all but 1 case.

Opacification of the kidney is stressed as a sign of ureteral blockage. It was observed in 5 cases of calculous and 5 cases of noncalculous ureteral obstruction.

Intravenous urography is recommended as a valuable diagnostic procedure in all cases of acute renal colic.

HEMOSTASIS

Fish⁴⁸ states that when gauze is oxidized with nitrogen dioxide it undergoes changes. A material that resembles ordinary gauze in appearance and texture results, but its chemical composition so changes that it possesses a pronounced hemostatic quality and becomes completely absorbed in animal and human tissues. Little or no reaction is present in the tissues in contact with the absorbable gauze during the period of its absorption. The rate of absorption depends on the amount of gauze used, the degree of trauma to tissue at the site of insertion and the amount of bleeding. This absorbable hemostatic gauze can be used in

47 Florence T J, Howland W S and Weens, H S. Intravenous Urography in Acute Renal Colic. *J Urol* 56:284-291 (Sept) 1946.

48 Fish G W. Oxidized Cellulose (Absorbable Hemostatic Gauze Cellulose Acid). Its Use in Genito-Urinary Surgery, *J Urol* 56:375-382 (Sept) 1946.

any tissue of the body to control bleeding not controllable by clamp ligature, suture or coagulation, and clinically it is nonirritating. Its hemostatic quality would seem in part to be due to a specific combination of the gauze with hemoglobin in solution or in the tissues. In combining with hemoglobin the gauze turns dark brown. When placed in contact with whole blood the gauze rapidly forms a brownish gelatinous mass and the bulk increases.

Fish first used the material for packing the prostatic bed following suprapubic prostatectomy. The result of this first trial was excellent, and since that time it has been used by him in more than 100 surgical urologic cases.

Some important technical details must be carried out if the gauze is to be used successfully. First and foremost, unless the gauze comes into intimate contact with a bleeding surface it cannot exert its hemostatic effect, and where active oozing is present the gauze must be kept in contact with the bleeding surface until hemostasis is established. This can be done by tamponading with ordinary gauze packing or by gauze sponge stick and sponge. Pressure rarely needs to be applied for more than two or three minutes. Secondly, a sufficient quantity of the gauze must be used to cover completely the entire area of bleeding, be it brain, liver, prostatic bed or kidney. Failure to carry out these two fundamental procedures will result in hemorrhage.

The gauze has been used for packing the prostatic bed following suprapubic prostatectomy in 108 cases. The gauze was first used in the form of 6 inch (15.2 cm) squares of four ply material. This was not entirely satisfactory, and 2 by 18 inch (about 5 by 46 cm) four ply rolls were used. After prostatic enucleation the gauze is put into the prostatic bed with sponge forceps and is pressed gently but firmly into the cavity. Pressure is then applied with a sponge stick for two to three minutes. One roll of 2 by 18 inch gauze is usually sufficient, but when large glands have been removed it may be necessary to use two to four of these rolls to cover the bleeding surface completely. When hemostasis has been established, the bladder is closed about a suprapubic tube in the usual manner. As a rule, the suprapubic tube is removed on the fourth postoperative day. Usually the gauze is absorbed completely by the tenth postoperative day. When large quantities of the gauze have been used and it seems advisable to hasten its removal the bladder may be irrigated daily through the suprapubic sinus with a 5 per cent solution of sodium bicarbonate, as the absorbable gauze readily dissolves in weak alkaline solution.

An absorbable hemostatic packing of this kind seems to possess the following distinct advantages: The amount of postoperative bleeding has been greatly reduced by this material as compared to packing with ordinary gauze or with hemostatic catheters or bags. Secondary hemor-

rhage after removal of ordinary gauze packing and the unavoidable pain of removal have been done away with. One other possible source of trouble must not be overlooked. If a large amount of absorbable gauze has been used and it has been tightly packed in the prostatic bed, healing may be more rapid than the absorption of the gauze, and when the patient is ready to void some of the material may still be present in the lower part of the prostatic bed. Under such circumstances the passage of a silk or metal catheter through the urethra will dislodge the unabsorbed material and the bladder may be irrigated from below with a 5 per cent solution of sodium bicarbonate.

The bleeding encountered in renal incisions of any type can be well controlled in almost every instance by proper application of absorbable gauze. Here again pressure for a short time is important. It was found that 2 by 2 inch (about 5 by 5 cm) four ply gauze packs and 4 by 4 inch (about 10 by 10 cm) four ply gauze packs are the most useful. These pieces may be made into small tufts or wicks and placed in the site of incision for nephrostomy and held in place with plain catgut mattress sutures.

When large staghorn calculi are removed by splitting the kidney from pole to pole and the actively bleeding vessels ligated, a thin pad of absorbable gauze is placed between the halves of the kidney and held in place with three or four large mattress sutures of no. 0 catgut. The gauze is particularly useful for the control of bleeding in renal beds from which large adherent kidneys have been removed and when a bed of scar tissue or an oozing bed such as those encountered in tumors presents a problem in hemostasis. In these cases the 6 by 6 inch (about 15 by 15 cm) pieces of four ply gauze as a postoperative packing are excellent. They are also useful at the site of various renal incisions familiar to every urologic surgeon. The bleeding at the site from which a renal specimen has been removed for biopsy is easily controlled when small pieces of the gauze are applied with fine mattress sutures of plain catgut.

The Foley-Hendrickson bag which is designed especially for hemostasis with clotting agents was found by Hendrickson⁴⁹ to be extremely effective in 470 transurethral resections of the prostate gland.

The value of cloth tampons saturated with clotting agents in promoting hemostasis has been demonstrated in animals and confirmed clinically. The problem of control of bleeding following suprapubic prostatectomy has been solved without incurring the risk of infection and secondary hemorrhage, which so frequently have followed the use of the ordinary gauze pack.

49 Hendrickson F C. Topical Use of Clotting Agents in Surgery of the Prostate Gland, *J Urol* 55 613 617 (June) 1946

STEEL SUTURES

Powell⁵⁰ discusses the use of alloy stainless steel wire in the closure of urologic wounds in 37 surgical cases. Renal, ureteral and prostatic operations and operations on the bladder were performed in these cases. The general procedure is as follows. The wire should be kept on a spool to prevent kinking or twisting. The wire is cut in 8 inch (about 20 cm) lengths with a wire cutter or a pair of scissors and is threaded through a large, curved cutting needle. Approximately 2 inches (about 5 cm) of the wire is bent back after the end of the wire is passed through the eye of the needle. Using a needle holder, the suture is carefully placed to approximate the wound edges in the usual stay suture technic. The suture is inserted through skin, muscles and fascial layers in that order and is drawn out the other side of the wound through these tissues in reverse order. Sutures are placed every $\frac{1}{2}$ to $1\frac{1}{2}$ inches (1.3 to 3.8 cm) in order to secure adequate approximation. All sutures are placed before any is tied. After the first throw is tied, the assistant grasps it with the end of a hemostat without clamping. The surgeon then ties the second throw of a square knot, taking care to evert the margins of the skin. If necessary, interrupted "dermal" sutures can be placed to approximate edges of skin. The technic allows for rapid closure, quick healing, minimal tissue reaction and good functional results.

Alloy stainless steel wire possesses the following advantages that would seem to make it an almost ideal suture. It (1) has high tensile strength per unit of diameter, (2) does not give rise to capillary action, (3) is malleable, (4) is not affected by any body fluids, (5) gives rise to minimal tissue reaction, (6) is relatively easy to handle, (7) is inexpensive, (8) is easy to sterilize, and (9) is able to stand repeated sterilization.

Its disadvantages are that (1) kinking or twisting weakens its tensile strength, (2) the ends of the suture tend to stick gloves, fingers of the surgeon or both, (3) there is almost complete lack of elasticity, and (4) wire cannot be used to suture renal parenchyma, ureter or vesical wall.

WAR WOUNDS

Kimbrough⁵¹ reports on war wounds of the urogenital tract and the treatment of neurogenic bladder (neurogenic vesical dysfunction). Hematuria was the most common symptom of wounds of the kidney, and the importance of conservative treatment rather than early exploratory operation in cases of renal injury is emphasized.

50 Powell, N. B. The Use of Alloy Stainless Steel Wire in Closing Urological Wounds, *J Urol* 56:35-45 (July) 1946.

51 Kimbrough, J. C. War Wounds of the Urogenital Tract. *J Urol* 55:179-189 (Feb) 1946.

Ureteral injuries are rare probably because they are associated with such severe injuries that death occurs before the patients reach hospital facilities. Ureteral injuries should be repaired at the first operative procedure.

Early determination of the extent of injury of the bladder is imperative, as early drainage, usually by cystostomy, is necessary in cases of penetrating wounds. Rarely is drainage by means of a catheter satisfactory. In general, the important aspects of treatment in injury of the bladder are (1) control of hemorrhage and shock, (2) drainage by cystostomy and (3) repair of the wound.

Kimbrough states that the type and gravity of vesical dysfunction depend on the location of the lesion of the brain or cord and the severity of the damage. As soon as the presence of neurogenic bladder is determined, insert a urethral catheter and leave it in place until the patient recovers, dies or undergoes cystostomy. Maintain continuous catheter drainage (tidal or otherwise) until vesical function is recovered, or it is determined that recovery will not occur. Perform suprapubic cystostomy at the end of four weeks, or earlier if definite evidence of return of vesical function is not found, provided that the general condition of the patient is such that the operation offers reasonable life expectancy.

Do not permit the bladder to become overdistended. Do not depend on spontaneous overflow or manual expression of urine. Do not depend on intermittent catheterization. Do not leave the catheter in place in the presence of severe infection.

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